DUKE ENERGY®

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September 22, 2016

VIA ELECTRONIC FILING

Chief Clerk
North Carolina Utilities Commission
4325 Mail Service Center
Raleigh, North Carolina 27699-4300

RE: Duke Energy Carolinas, LLC and Duke Energy Progress, LLC's Response to September 8, 2016 Order Requiring Response and Requesting Comments
Docket No. E-100, Sub 101

Dear Chief Clerk:

I enclose Duke Energy Carolinas, LLC and Duke Energy Progress, LLC's Response to the September 8, 2016 *Order Requiring Response and Requesting Comments* for filing in connection with the referenced matter.

Thank you for your attention to this matter. If you have any questions, please let me know.

Sincerely,

Lawrence B. Somers

Enclosures

cc: Parties of Record

<u>Question 1.</u> How does Duke define a "utility-scale" solar generator?

For purposes of Duke Energy Carolinas, LLC's ("DEC") and Duke Energy Progress, LLC's ("DEP" and collectively "Duke" or "the Companies") implementation of the circuit stiffness review ("CSR") screening criteria, as identified in the Settlement Agreement, Duke has generically used the term "utility scale" to include proposed generator interconnection requests seeking to interconnect to the Companies' distribution systems under the North Carolina Interconnection Procedures ("NCIP") Section 4 study process. Generally, under the NCIP, this includes proposed distributed generators with an AC output greater than or equal to two megawatts nameplate ("MW"). Smaller generators that fail the NCIP Section 3 Fast Track study process would also be reviewed under CSR.

As described in the Settlement Agreement, Duke is applying the CSR screening criteria to all utility-scale generators that had not obtained a fully-executed Final Interconnection Agreement ("IA") and paid associated Upgrades by July 7, 2016 under NCIP Section 5.2.4. This includes both solar and non-solar proposed generator interconnection requests.

<u>Question 2.</u> (a) Please identify exactly which customers have experienced degradation of electric service due to utility-scale solar facilities. (b) How did DEC or DEP become aware of the problem(s)? (c) Have the problems been resolved, and if so, how? (d) If not, what is the plan for resolving these service issues?

See Duke Response Attachment 1, identifying solar generator-related power quality events on the DEC and DEP systems and the status of such events.

See Duke Response Attachment 2 for more detailed Power Quality Incident technical engineering analyses of certain of these events, which were developed at the request of Public Staff and provided to the Public Staff on July 8, 2016.

As shown in these two Attachments, the majority of the experienced power quality issues have arisen since the beginning of 2016. As Duke continues to gain experience with the interconnection and parallel operation of utility scale solar generators on the distribution system, the Company believes other problems may exist but have not yet been identified. Duke is especially concerned that power quality issues may be occurring in remote areas of the distribution system where the system is electrically weaker, and customers are generally residential or small commercial and do not have the sensitive electrical equipment that a typical industrial customer would have and would cause them to notify Duke of adverse or abnormal power quality events impacting their operations. To address these concerns, Duke intends to continue to allocate specialized distribution system engineering resources to evaluate other distribution feeders and solar sites to assess whether any other degradation in electric service is occurring.

In at least one instance, to date, Duke has also recently invoked its rights under the Section 3.4.4 Adverse Operating Effects provision of the North Carolina IA, by putting an interconnection customer on notice that its generator had caused disruption of service to other customers served on the same distribution circuit, and notifying the Interconnection Customer that its generator could be subject to disconnection if the power quality impact is not remedied (including procedures put in place to assure it does not reoccur) within a reasonable time.

Duke has also been challenged during System Impact Studies to meet interconnection customers' cost and siting expectations while also ensuring that the value of the DEP DSDR system is maintained. This has been especially significant with projects being proposed several miles from the substation and behind electrical equipment that Duke utilizes to maintain levelized voltage across the distribution feeder. In one instance so far, Duke has disabled the DSDR system on the distribution feeder to allow a solar PV project to continue operation while the facility owner worked with the inverter manufacturer to implement corrective actions at the solar facility. Duke has since re-enabled the DSDR system, while the inverter manufacture continues to seek a remedy for their inverter.

To summarize, Duke is taking a three-pronged approach to ensure that the interconnection and parallel operation of solar generators meet the foundational principle that integrating Qualifying Facilities should "do no harm" to power quality on its system or to the reliability of electric service delivered to retail customers:

1. Integrate CSR and other "advanced study" criteria into the System Impact Study process to ensure proposed generator interconnections will not adversely impact electric power system operations or the quality of power delivered to retail customers;
2. Allocate specialized distribution system engineering resources to respond to retail customer power quality concerns as well as more broadly investigate distribution feeders on the system to assess whether any other degradation in electric service is being caused by a solar PV site; and
3. Exercise Duke's rights under the IA if emergency conditions or potential adverse power quality events arise from the operation of an interconnected generator (both solar and non-solar alike), and then work with the Interconnection Customer to determine solutions that avoid recurrence of adverse power quality events.

<u>**Question 3.**</u> **How is it that Duke's earlier process for evaluating interconnection requests failed to identify and prevent these service issues?**

Duke is leading the nation in utility scale solar generators requesting to interconnect to the distribution system. Since January 1, 2013, DEC and DEP have interconnected a significant number of Interconnection Customers' generation projects to their respective distribution systems.

	Projects	Nameplate Capacity
DEC	96	265 MW_{AC}
DEP	191	812 MW_{AC}

Nowhere in the country has more utility-scale solar been interconnected to a utility's distribution system in such a short period of time than in the DEP service territory. North Carolina is also now second in the nation for installed solar capacity. As of August 31, 2016, DEC and DEP also have a combined 6,532 MWs of additional proposed utility-scale generation requesting to be studied for interconnection to the Companies' distribution systems.

The proliferation of distribution-connected utility scale solar generators in DEP's service territory is notable, as these projects are being proposed in the rural areas desirable for many solar developers (relatively flat, available and lower cost land), but where the grid infrastructure is weak and "stiffness" of the electric power system infrastructure is also lower. In light of this recent experience, Duke has become the "living laboratory" for evaluating interconnection and parallel operation of distribution-connected utility scale solar projects nationally.

In implementing the NCIP, Duke has appropriately applied System Impact Study models and methodologies based on historically valid engineering standards that have been applied for decades to study generators proposing to interconnect to Duke's and other utilities' transmission and distribution systems. These existing System Impact Study models have assumed that studies would be completed essentially one by one, and never contemplated the scale, volume, and interdependent nature of utility-scale generator interconnection requests that DEC and DEP are experiencing today in their interconnection queues.

Duke's recent experience as significant numbers of utility scale Distributed Energy Resources have become interconnected and begun operating in parallel with Duke's power system is that certain of these historically valid "steady state" engineering studies are inadequate to properly predict power quality issues associated with utility-scale projects connected to the distribution system. These traditionally accepted steady-state models of the past need to be advanced to include dynamic models that simulate the dynamic nature of loads and distributed generation. The circuit stiffness ratio being used as a screen is a first step in the development of these more robust and dynamic models.

<u>Question 4.</u> Are any of the solar facilities that DEC or DEP owns, or proposes to own, causing service problems for retail customers?

No. DEC and DEP-owned solar generating facilities in North Carolina include:

Utility	Project	Nameplate (MW AC)	Transmission/ Distribution Connected
DEP	Warsaw	65 MW	Transmission 230KV
DEP	Elm City	40 MWs	Transmission 115KV
DEP	Camp Lejuene	13 MW	Distribution 12KV
DEP	Fayetteville	23 MW	Transmission 115KV
DEC	Monroe	60 MW	Transmission 100KV
DEC	Mocksville	15 MW	Transmission 44KV
DEC	Woodleaf*	6 MW	Distribution 12KV

*failed the CSR and is subject to an Advanced Study

Any potential outages and electrical faults at the five transmission-connected facilities would typically not be seen by retail customers since these generators are connected to the transmission system where the electric power system is strong enough to "absorb" electrical faults or other disturbances without impacting retail customers on the distribution system. Five out of the six interconnected Duke-owned sites are located on the transmission system, and this is the preferred location for utility-scale project interconnections. The Camp Lejuene site is connected at distribution voltage, but immediately outside of the substation serving the military base and where the substation size and feeders ensure a strong interconnection. As noted above, Duke is applying the CSR screening criteria to its proposed utility-owned solar generators as well.

<u>Question 5.</u> What costs will Duke incur to track the power quality monitoring equipment that it installs pursuant to the settlement agreement, and who will absorb those costs?

Power quality monitoring equipment and installation costs will be charged to the Interconnection Customer under IA Appendix 2, as a component of Interconnection Facilities. The operation and maintenance of the equipment will be recovered through the Interconnection Customer's monthly facility cost. The cost of the metering equipment and installation is expected to be approximately $25,000, and will be subject to final true up under IA Section 6.1.

Importantly, Duke's cost to monitor the power quality equipment and investigate potential adverse power quality events is not currently being covered by the monthly charge being calculated in the extra facility program. In Duke's view, this program needs to be re-assessed to cover the on-going operational costs for this monitoring, switching and other cost that are increasing as a result of interconnecting and operating in parallel with these facilities.

Question 6. Will the monitoring occur "real time," or after the fact?

The monitoring equipment will capture in "real time," or down to the millisecond, the power quality at the point of interconnection. This information will be downloaded to a Duke-owned computer server for ongoing monitoring and for follow-up investigations if customer complaints or other issues arise on the distribution circuit.

Question 7. What criteria will Duke use to determine that a given solar installation is causing reliability problems for retail customers and, hence, is subject to disconnection pursuant to the settlement agreement?

In evaluating whether adverse power quality conditions or emergency conditions have occurred or are likely to occur, Duke shall apply engineering standards applicable to interconnected generators, including industry-accepted operating criteria as defined in the IEEE 1547 for power quality issues such as Voltage, Frequency, Harmonic and Flicker, as well as National Electric Code-compliant construction standards. When these standards are violated, Duke will notify the Interconnection Customer pursuant to IA Section 3.4.1 or 3.4.4 and then work with the Interconnection Customer to evaluate proposed mitigation solutions to meet compliance with the standards.

So far, and without easy access to power quality monitoring equipment, Duke has been very careful and diligent in evaluating whether adverse power quality experienced by a retail customer is being caused by a given Interconnection Customer's installation. Duke also recognizes the potentially significant financial implications of disconnection for interconnected generators, and is committed to working with interconnection customers to design solutions that avoid disconnection to the extent such solutions resolve adverse power quality impacts to Duke's system or to other customers.

Question 8. The amendments to the standard interconnection agreement (Exhibits A, B, and C of the settlement agreement) appear to apply only to those projects that are listed on the signature pages of the settlement agreement. Please confirm that this is so.

The Exhibit B and C amendments to IA Sections 3.4.4. and 7.3.2 are only applicable to Interconnection Customer generators that are included in the Settlement Agreement.

Duke intends to include power monitoring equipment similar to the equipment identified in Exhibit A as standard Interconnection Facilities for all planned distribution-interconnected utility scale generators in the future. While not specifically addressed in

Exhibit A, Duke is also including a requirement in Appendix 5 that Interconnection Customers adhere to the Duke distribution system construction standards. The construction standards requirement had been driven in part from reliability issues caused by electrical faults at several solar installations, but is also being driven from follow-up inspections that Duke has performed, which have shown significant construction workmanship issues, engineering design deficiencies, and violations of the National Electric Code.

Question 9. **As a result of the service degradation problems that Duke referred to in its August 29, 2016 submittal letter, does Duke anticipate requesting changes to the Commission-approved interconnection standard, process, or contract forms? If yes, in what timeframe?**

As described above, Duke has gained significant experience studying, interconnecting and operating its electric power system in parallel with utility-scale generators interconnected to its distribution system since the Commission's North Carolina-jurisdictional NCIP standard, forms and agreements were last reviewed in 2014 and approved in May 2015. Under the existing NCIP, Duke believes it has sufficient flexibility to take needed steps, such as incorporating CSR and advanced study criteria into the System Impact Study process, to improve the interconnection process and mitigate potential future adverse power quality impacts to retail customers and Duke's system. However, Duke also believes that the NCIP standard and associated forms, including the standard IA, should be evaluated in the near future based upon Duke's experience. Duke has been hosting ongoing stakeholder meetings since the Commission's May 15, 2015 Order Approving Revised Interconnection Standard in Docket No. E-100, Sub 101 ("Order") and anticipates sharing this experience and recommending improvements, as part of that informal stakeholder process, as well as part of the formal working group process provided for in the Order.

Customers Experiencing Degradation of Electric Service Due to Utility-Scale Solar Facilities

AEO: Adverse Operating Effects *DER: Distributed Energy Resource* *PQ: Power Quality*

Utility	Location of Adverse PQ Event on Utility System	a) Impacted Retail Customer / Impact to Duke System Operations	b) Description of Adverse PQ Events	c) Assessment of PQ Event	d) Resolution of PQ Event	Additional DERs Connected or Requesting Interconnection to Impacted Local Distribution System
DEP	Maxton Airport 115KV	Campbell's Soup Company Maxton, NC	On 2 occasions in February 2016, the 20MW Holstein Solar PV facility suffered outages due to electrical faults within the facility. Each time Duke learned shortly after the events that Campbell's Soup had experienced partial equipment shutdowns and lost production at the same time as the events occurred. A third event occurred in May again causing equipment shutdowns and lost production at Campbell's Soup.	Holstein Solar has corrected the construction deficiencies and clearance issues that caused the first 2 outages. To mitigate the 3rd event type, Duke has disabled the reclosing capability at the solar site recloser, and now requires the solar site to be re-energized in stages. This is a temporary solution, and Duke is working with the Interconnection Customer to develop a permanent solution. So far, the problems have not re-occurred.	Duke has provided Holstein Solar with a formal notice under IA Section 3.4.4 Adverse Operating Affects requiring Holstein Solar to provide a permanent solution.	(1) 4.5 MWs solar PV facility proposed
DEP	Elm City 115KV	Southeastern Diesel Services Elm City, NC	The customer reported on several occasions concerns about equipment malfunctions at their facility in late December 2014.	After the first event, Duke installed power monitoring equipment at the (2) 5MW solar PV facilities located on the distribution circuit, and within a week of the first event, Southeastern Diesel again reported problems. The newly installed power monitoring equipment was also able to detect another situation later on in March 2016, where high levels of harmonic distortion were seen at one of the solar sites (Fresh Air XII) when another solar site on the feeder was re-energized. Duke did not hear of specific customer complaints associated with this issue related to harmonics, but the harmonics seen were significant and could have the potential to impact surrounding customers, or future customers more sensitive to power quality degradation. Duke has not taken specific action as of this filing, and is currently evaluating appropriate steps to resolve these events.	Duke staff spent some time processing the data from the March 2016 event and reviewing internally, since Southeastern Diesel was not impacted by that noted event. Duke has now determined that this event is significant enough to warrant investigation with the solar site owner. As of this filing, Duke engineers are investigating the event and is contacting the Fresh Air XII solar site owner so the owner and inverter manufacturer can be made aware and make attempts to correct.	None
DEP	Biscoe 115KV	Fidelity Bank Biscoe, NC	The customer contacted Duke after experiencing excessive banking equipment interruptions (UPS devices switching on and off).	This problem has not been resolved.	Power monitoring equipment has been installed at the 20MW Montgomery Solar facility. Duke engineers are evaluating recent event data to determine a solution, which may require the bank to re-engineer their UPS system.	(1) 5MW solar PV facility connected, (1) 2.3MW solar PV facility proposed
DEC	Bellwood Retail 1202 44KV	Rutherford EMC	Rutherford EMC contacted Duke about low voltage at their delivery point.	This problem was ultimately resolved after Duke upgraded the 44KV transmission delivery point to a 115KV delivery point. This solution was completed after earlier solutions had failed including capacitor bank installations, and manual transformer voltage tap changer adjustments that were made between summer/winter, and spring/fall.	Transmission system upgrades as noted. As part of the pre-request procedure, Duke has discouraged additional DG facility proposals by informing potential interconnection customers that significant transmission upgrades are required to accommodate additional interconnections.	none

Utility	Location of Adverse PQ Event on Utility System	a) Impacted Retail Customer / Impact to Duke System Operations	b) Description of Adverse PQ Events	c) Assessment of PQ Event	d) Resolution of PQ Event	Additional DERs Connected or Requesting Interconnection to Impacted Local Distribution System
DEP	LaGrange 115KV	Wayne III Solar LaGrange, NC	The solar facility operator complained to Duke about excessive plant outages.	Earlier in 2016 Duke engineers participated in a number of meetings with the solar facility operator and the inverter manufacturer. Duke shared the power quality data it had acquired that showed the inverters at the site were reacting to normal capacitor bank switching operations on the distribution feeder. The inverter manufacturer agreed that the inverters were not operating appropriately and likely needed software and hardware upgrades, but that it would take at least 16 weeks for that to occur. To allow time for the solar site to mitigate their inverter issue, Duke temporarily disconnected a capacitor bank which was causing the solar site to de-energize, but has recently re-connected the capacitor bank as of August 2016. To Duke's knowledge, no inverter upgrades have been initiated. Duke has not received any additional complaints or requests for assistance from the interconnection customer.	Duke is currently monitoring the performance of the site since the capacitor bank was re-enabled.	(1) 5MW solar PV facility is under construction and (1) 4.5MW solar PV facility is proposed
DEP	Roseboro 115KV	Black Creek Renewable Energy 9MW landfill gas project	This landfill project contacted Duke after experiencing numerous nuisance plant trips associated with nearby capacitor bank operations. This incident was not caused by utility scale solar, but the issues experienced at the facility are similar to incidents being caused today at solar facilities. This problem occurred several years ago.	It was determined that Duke's interconnection protection was tripping due to a phase angle monitoring and protection function at Duke's interconnection recloser. It was determined after meetings between Duke staff and the plant operator that the plant's governor control systems could not keep up with the transient phase angle shifts caused by nearby switching of a 1200 kVAR capacitor bank.	The problems were resolved after removal of one 1200 kVAR capacitor bank on the feeder, and installation of two smaller 600 kVAR capacitor banks.	(2) 2MW solar PV facilities connected, (3) 5MW solar PV facilities proposed
		9 additional solar PV sites are being investigated for excessive recloser operations at each site causing the solar sites to de-energize. These sites are identified below.	These problems were identified by Duke engineers after reviewing recloser data from all solar sites. These 9 sites distinguished themselves from other sites by having at least 20 recloser operations within a one month time span in July 2016.	These problems have not been resolved, and Duke is continuing to investigate. Initial investigations indicate the *reclosers* are tripping after seeing sudden phase angle shifts at the point of interconnection. Duke expects the solar sites to operate with a stable phase angle/power factor at the point of interconnection. At this point, the data collected could indicate excessive sensitivity of the generating equipment to normal distribution system operation, but more investigation is needed.	Duke has not notified these project owners yet, but intends to do so after eliminating any other possible cause for the recloser operations. As Duke works to gain a better understanding of these events, the Company may also involve the inverter manufacturers in the process of developing acceptable solutions to eliminate these problems.	
DEP	Bridgeton 115LV	5MW Porter Solar				(1) 5MW solar PV facility connected, and (1) 400KW diesel facility proposed

Utility	Location of Adverse PQ Event on Utility System	a) Impacted Retail Customer / Impact to Duke System Operations	b) Description of Adverse PQ Events	c) Assessment of PQ Event	d) Resolution of PQ Event	Additional DERs Connected or Requesting Interconnection to Impacted Local Distribution System
DEP	Fairmont 115KV	5MW FLS Solar 260				(1) 5MW, (1) 3.5MW, (1)4.3MW solar facilities connected, (4)2MW, (5) 5MW solar facilities proposed
DEP	Four Oaks 230KV	5MW ESA Four Oaks NC 1 solar				(1) 1760KW land fill gas, (1).8MW, (2)5MWsolar PV facility connected, (1) 2MW solar PV facility proposed
DEP	Henderson East 230KV	5MW Melinda Solar				(4) 5MW, (1) 3MW, (1) 100KW, (1) 125KW solar PV facilities connected, (7) 5MW, (1)3MW, (1) 2MW solar facilities proposed
DEP	Henderson North 115KV	5MW Stagecoach Solar				(1) 5MW solar PV facility connected, (6) 5MW, (1) 4MW, (1) 4.2MW solar PV facilities proposed
DEP	Laurinburg 230KV	5MW TWE Laurinburg Solar				(1) 5MW, (3) 2MW, (1) 193KW solar PV facilities connected, (2) 5MW solar PV facilities proposed
DEP	Mt. Olive West 115KV	5MW Mt. Olive Solar 1				(3) 5MW, (1) 2MW solar PV facilities connected, (3) 5MW, (1) 2MW, (1) 800KW solar PV facilities proposed
DEP	Wadesboro 230KV	5MW Mills Anson Farm				(1) 5MW solar PV facility connected, (1) 20 MW, (1) 5MW solar PV facility proposed
DEP	Selma 230KV	5MW Nitro Solar				(2) 5MW, (1) 123KW, (1) 75KW solar PV facilities connected, (1) 5MW solar PV facility proposed

<u>General Notes:</u> Most of these issues have arisen since the beginning of 2016 after energizing more than twice as much solar as had been energized in all previous years combined.
Duke believes other problems may exist but have not yet been identified, and therefore Duke intends to continue to investigate and evaluate other distribution feeders and solar sites to determine any other degradation in electric service that might be caused by a solar PV site. In general, Duke is seeing all of these issues occurring in more remote areas of the distribution system where the system is electrically weaker, and customers are generally residential or small commercial and do not have the sensitive electrical equipment that a typical industrial customer would have.

Duke has also begun issuing formal notices to facilities pursuant to Section 3.4.4 Adverse Operating Effects of the North Carolina Interconnection Agreement. Duke intends to work with the generator owners to develop and implement acceptable solutions resolving experienced

PUBLIC STAFF DATA REQUEST
July 8, 2016

DUKE ENERGY CAROLINAS, LLC AND DUKE ENERGY PROGRESS, LLC
Interconnection process changes

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Questions related to Duke Energy's changes to interconnection study review process to address power quality issues, as presented on June 24, 2016

Power Quality Incident #1: Feb 2016, 20 MW solar farm, Maxton Airport 115 kV substation

1. Please provide a brief summary of each of the power quality incidents on the DEC and DEP system that have occurred in the past two years that may have involved the addition of distributed generation systems, including the following:
   a. Date of the incident.
      i. February 11, 2016, and February 26, 2016

   b. Description of the incident, including specific details on any outages or power fluctuations that occurred.
      i. On February 11, 2016, at 10:45:24.595, a fault occurred within the Strata Solar / Holstein Holdings 20 MW solar farm. Duke Energy's Rockwell feeder circuit breaker relaying responded and the breaker tripped, and Duke's interconnection recloser at the site tripped open and locked out. The feeder breaker then reclosed and restored service to the feeder. (Note: Such operation is expected for typical DEP coordination practices, which usually include a "fast curve" in the relay to assist with fuse saving protection schemes.) Duke Energy received word shortly afterwards that Strata personnel had traveled to the site to discover a fused cutout had operated within the solar site, and that Strata personnel had proceeded to replace the fuse at the site. Duke Energy personnel, in the process of corresponding with Strata, had requested information as to the source of the fault, but Strata replied that they had not been able to ascertain any root cause and simply replaced the fuse anyway.

         Duke Energy's feeder monitoring system registered and recorded the fault, which occurred at 10:45:24.595 on 2/11/2016. The fault started out as a "C" phase-to-ground fault, and within cycles changed to a "B"-to-"C" phase-to-phase-ground fault of approximately 3700 amps in magnitude. See Exhibit 1-1 for oscillography of the fault as recorded at the Rockwell feeder circuit breaker at the Maxton Airport 115 kV substation. The fault was also recorded within Duke Energy's interconnection recloser, with oscillography exactly consistent with the data from FMS.

See Exhibit 1-3 for a photo of Strata's medium voltage overhead facilities at the site, and see Exhibit 1-4 for an excerpt of Strata's one-line diagram which depicts the overhead facilities.

Duke Energy received word not long after this that Campbell Soup, a nearby industrial customer, suffered a partial facility shutdown that resulted in lost product.

A discussion ensued on the days after the event between Duke Energy and Strata as to the location of the fault. Duke Energy and Strata agreed to share fault event data. At first, Strata maintained that their check meter, located several spans beyond the Duke Energy recloser, had recorded fault current flowing from the generating site out towards Duke Energy's system. Duke Energy engineering staff reviewed data from both sources, and after further review, concluded that Strata's check meter did not properly record the flow of fault current, and that the fault was indeed beyond the recloser and check meter. The magnitude of fault current suggested that the fault was not very far beyond the point of interconnection, and since a fuse operated on one of the dip poles near the end of Strata's medium voltage overhead facilities, that it was likely just beyond one of those fuses.

ii. On February 26, 2016, at 10:45:49.987, a fault again occurred within the solar farm. Duke Energy personnel analyzed the fault data from FMS and ascertained that the incident appeared to be near identical to the February 11 incident. See Exhibit 1-2 for oscillography of the fault as recorded at the Rockwell feeder circuit breaker at the Maxton Airport 115 kV substation.

Duke Energy received word not long after this that Campbell Soup again suffered a partial facility shutdown that resulted in lost product.

Later that day on February 26, Duke Energy contacted Strata to inform them that Duke would be disconnecting the facility that day, and would reconvene with Strata on Monday February 29 to discuss next steps. On February 29, several Duke Energy personnel visited the Holstein Site, in conjunction with Strata personnel, and both parties conducted a visual inspection of Strata's medium voltage overhead facilities. Duke engineering staff on site determined that there were inadequate clearances between the many of the cable terminations and nearby ground wires (there to connect underground cable concentric neutrals to lightning arresters mounted above the cutouts). Duke and Strata personnel also both noted the brown flash marks at the bottom of the “C” phase cutout on the middle dip pole, and also flash marks on the “B” phase cable terminations. Duke further noted that the cable terminations were installed horizontally at the bottom of the cutouts, typically not a permitted installation method by termination manufacturers. See Exhibit 1-5 for a photo of the clearance issues, Exhibit 1-6 for a photo of the damaged cutout, and Exhibit 1-7 for a photo of the horizontally-oriented cable terminations.

Strata agreed to retrain/reroute the ground wires that day, since they had a distribution maintenance crew on site. Strata further agreed to replace the “C” phase cutout and to re-orient the cable terminations to be brought up vertically underneath the cutouts.

A series of actions took place in the days ahead in which Strata made repairs and prepared to restart the facility. After replacing the “C” phase cutout and re-energizing, a Duke technician performed a thermographic IR (infrared) scan of the middle dip pole, and discovered heating on the replaced cutout, implying a damaged cutout or a loose connection. See Exhibit 1-8 for a photo of the IR scan. Duke informed Strata, and they replaced the cutout a second time. By mid-March the facility was back on-line.

c. Utility customer that was impacted.
    i. Campbell Soup, which is served from the other feeder (the Campbell feeder) from Maxton Airport 115 kV substation..

d. Utility equipment, if any, that was impacted.
    i. No utility equipment was noted to have suffered damage.

e. Description of any damage suffered by the utility or its customer(s).
    i. According to Campbell Soup’s communications with Duke Energy, Campbell Soup suffered a process disruption to their industrial process coincident with each of the events noted. Campbell Soup has since filed a claimed with Duke Energy for financial compensation for lost product.

    Duke Energy is not aware of other customer complaints resulting from this event, but it should be noted that many customers do not register power quality complaints due to events that occur within minutes of another interruption.

f. Description of the substation, transformer, and other equipment on the substation or feeder.
    i. See Exhibit 1-9 for a one-line diagram of the Maxton Airport 115 kV substation. This substation is fairly typical of legacy Duke Energy Progress substations. The transformer is a 115 kV – 24 kV, 15 MVA capacity (nominal nameplate rating), with two stages of fans to allow loading at 20 MVA and 25 MVA, respectively.

The station is equipped with a three phase bus regulator, and there are two feeder breakers to serve the Campbell 23 kV feeder and the Rockwell 23 kV feeder.

g. Details of the distributed generation systems interconnected on the substation or feeder involved that may have contributed to the incident.

   i. Interconnected at DEP pole ID# 18BR16, the Holstein Holdings solar farm is a 20 MW PV generating facility. See Exhibits 1-10 and 1-11 for the distribution feeder topology that serves the facility. The POI is on the Rockwell feeder, approximately 1000' in electrical distance from the substation.

      See Exhibit 1-12 for an excerpt of the facility's one-line diagram. The facility consists of three grouping of three 2200 kVA transformers, each with an SMA 2200-US inverter, for a total of nine transformers and nine inverters.

Exhibit 1-1: 2/11/2016 fault event, as seen at the Rockwell feeder circuit breaker.

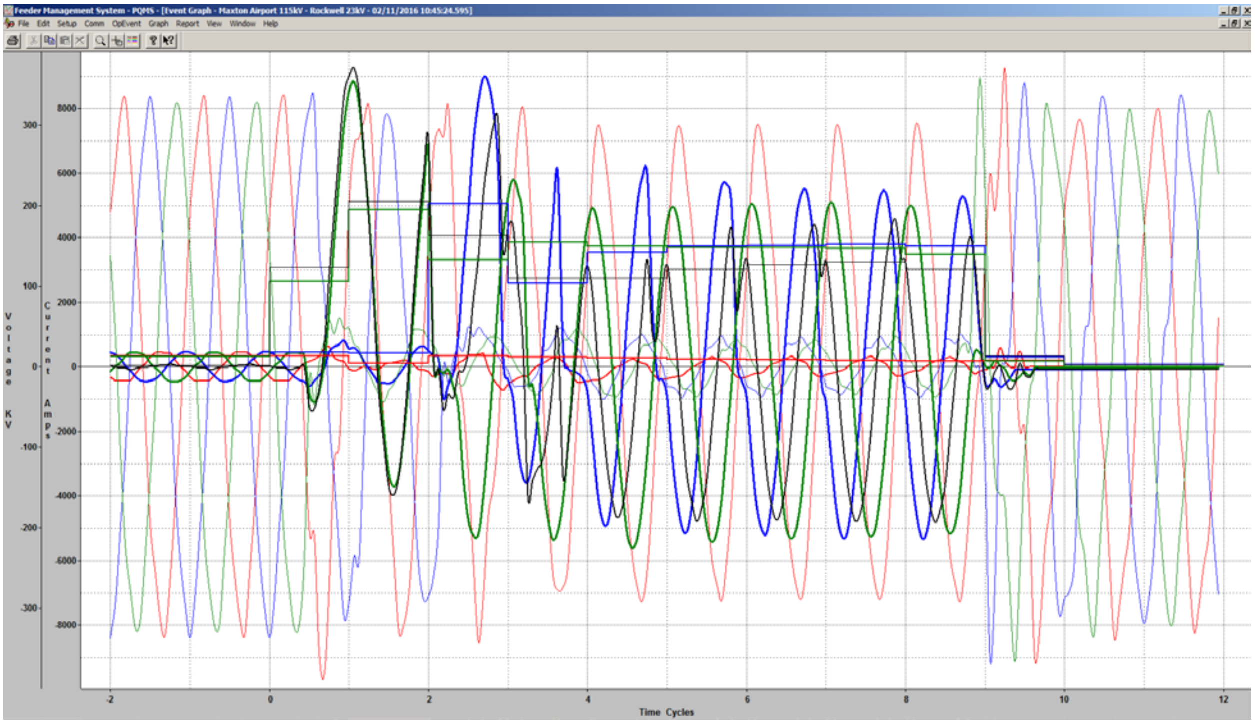


Exhibit 1-2: 2/26/2016 fault event, as seen at the Rockwell feeder circuit breaker.

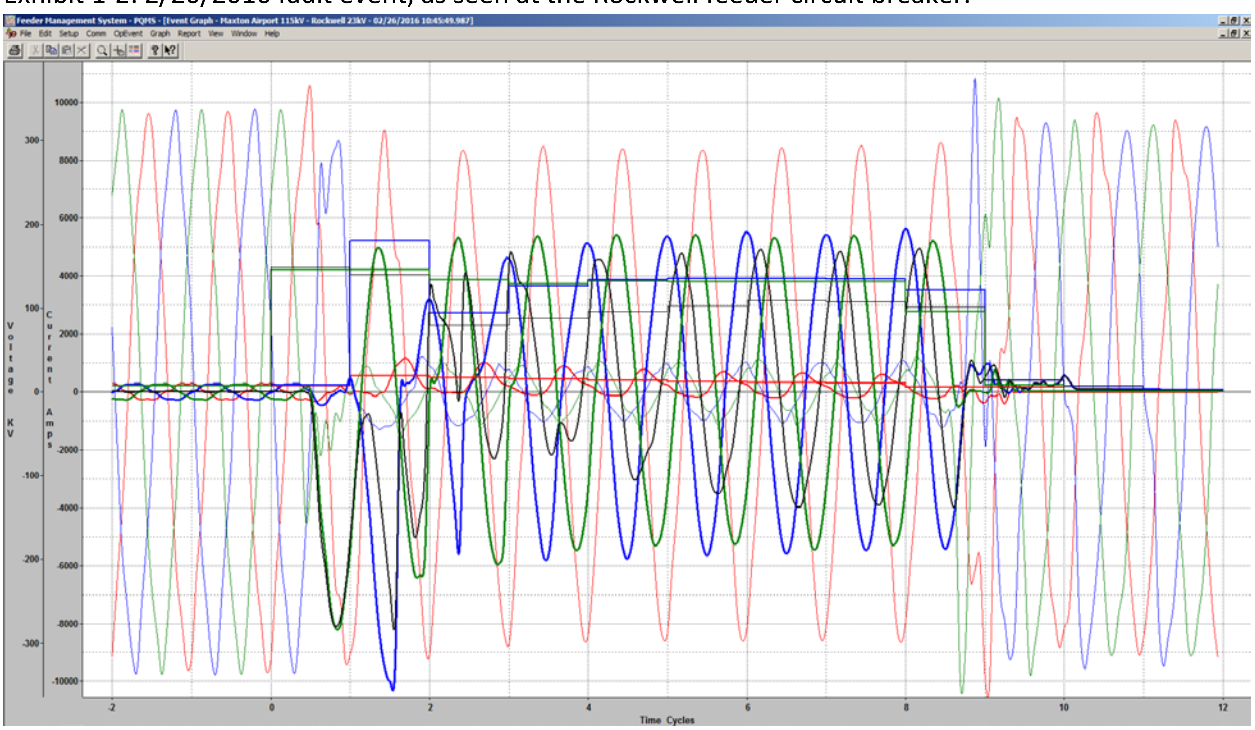


Exhibit 1-3: Overview photo of Holstein site medium voltage overhead facilities

Exhibit 1-4: excerpt of Strata's one-line diagram which depicts the overhead facilities

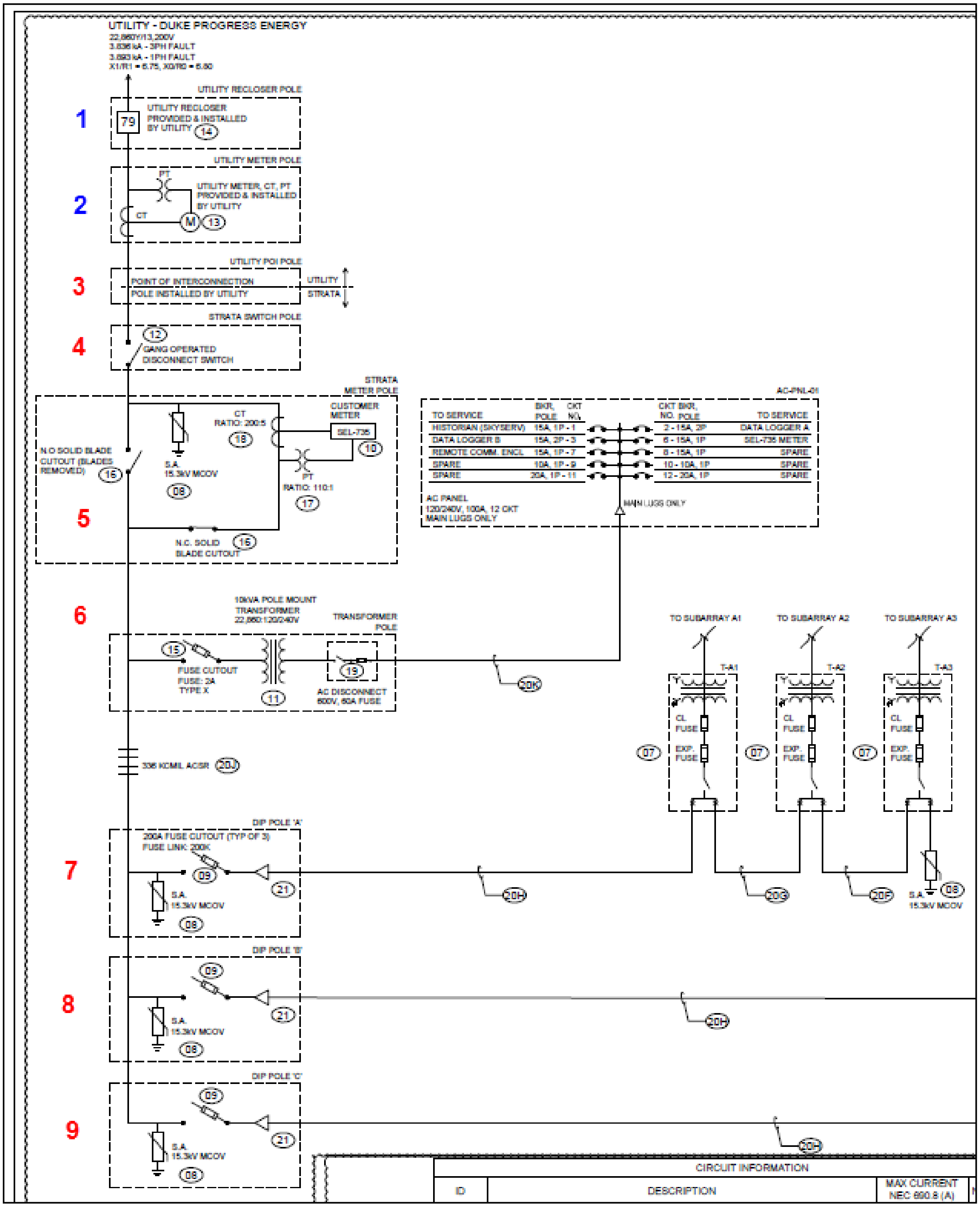


Exhibit 1-5: inadequate clearance between ground wires and cable termination

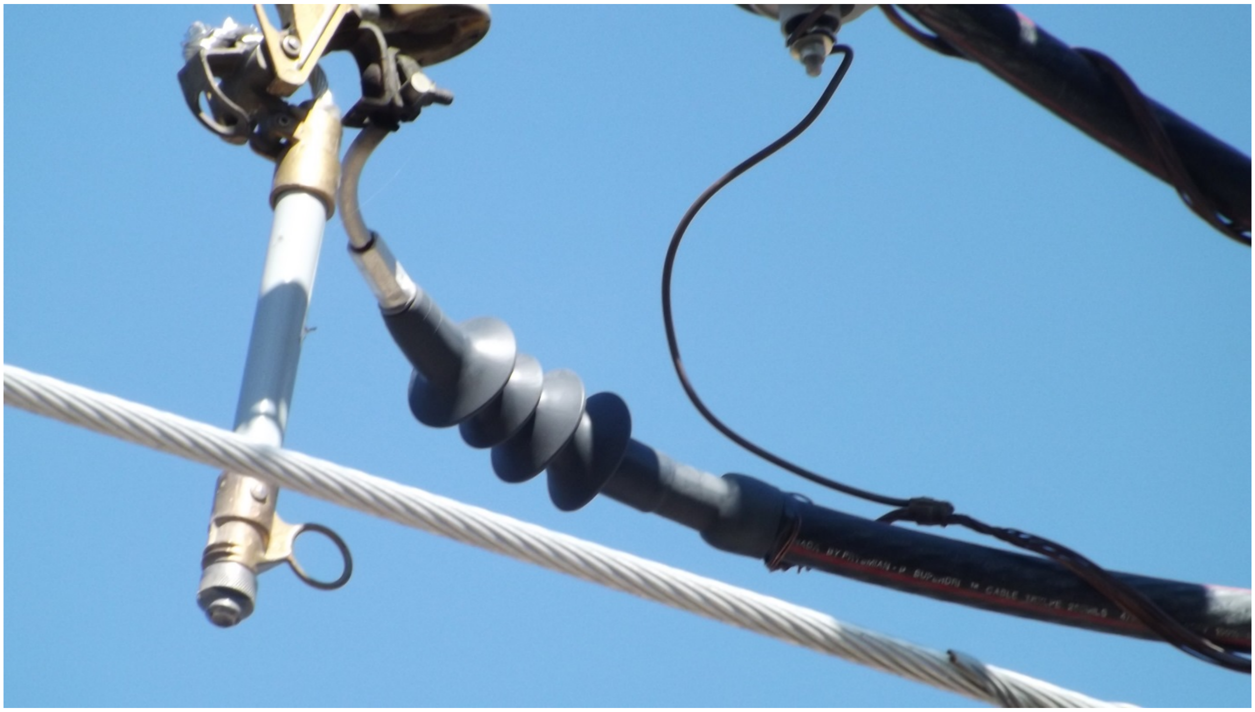


Exhibit 1-6: damaged cutout

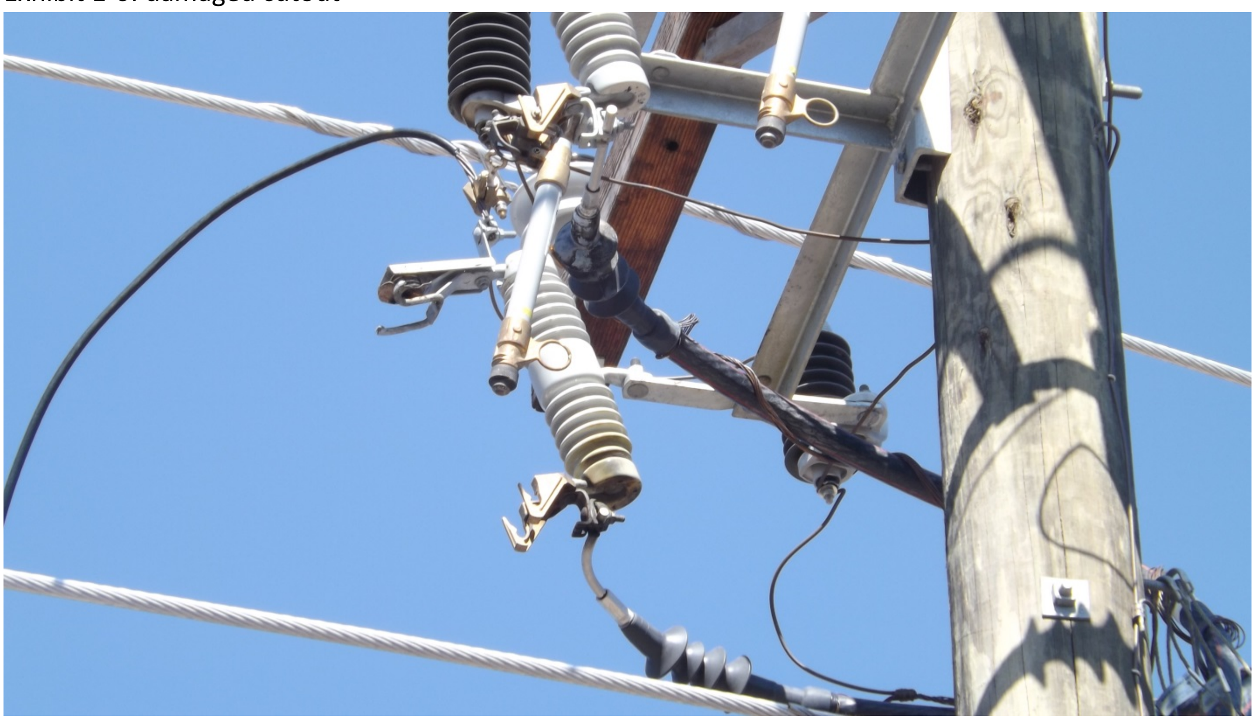


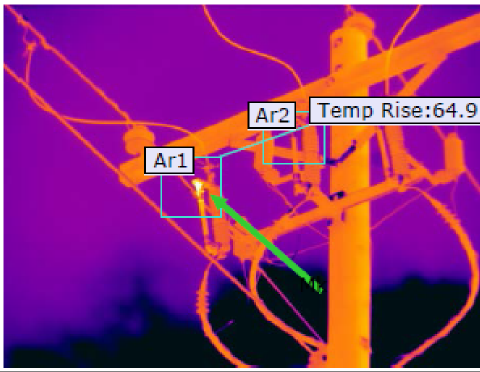
Exhibit 1-7: middle dip pole overview and view of horizontally-mounted cable terminations

Exhibit 1-8:

DUKE ENERGY. PROGRESS	**IR Scan Results**

Location Information

LOCID	Middle Customer Dip Pole
Reference Address	Solar Farm on Rockwell Feeder outside of Maxton



Date:	Time:	File Name:	
3/10/2016	1:00:26 PM	IR_2254.jpg	The field phase cutout barrel is starting to heat on jaw side or the Cap side of the barrel.

IR Information

Temperature Rise	64.9 °F	Condition	Serious
Point of Concern Temperature (Ar1)	145.2 °F	Upgrade	
Reference Temperature (Ar2)	80.3 °F		

Equipment Information

Voltage	Primary
Phase	Field
Equipment	Cutout Barrel
PMH Compartment	
PMH Section	

Comments/Recommendations:

This was a second follow up IR Scan on 3/10/2016 after this pole had been repaired from recent problems. This barrel should be inspected and repaired to stop the heating condition. This may be the fuse and cap not installed correctly or dirty contacts in jaw or barrel or the contacts in the jaw of the cutout not making good contact. Just wanted to make you aware of this condition. It was not heating on the scan the day it was put back in service but was today.

Exhibit 1-9: Maxton Airport 115 kV Substation, one-line diagram

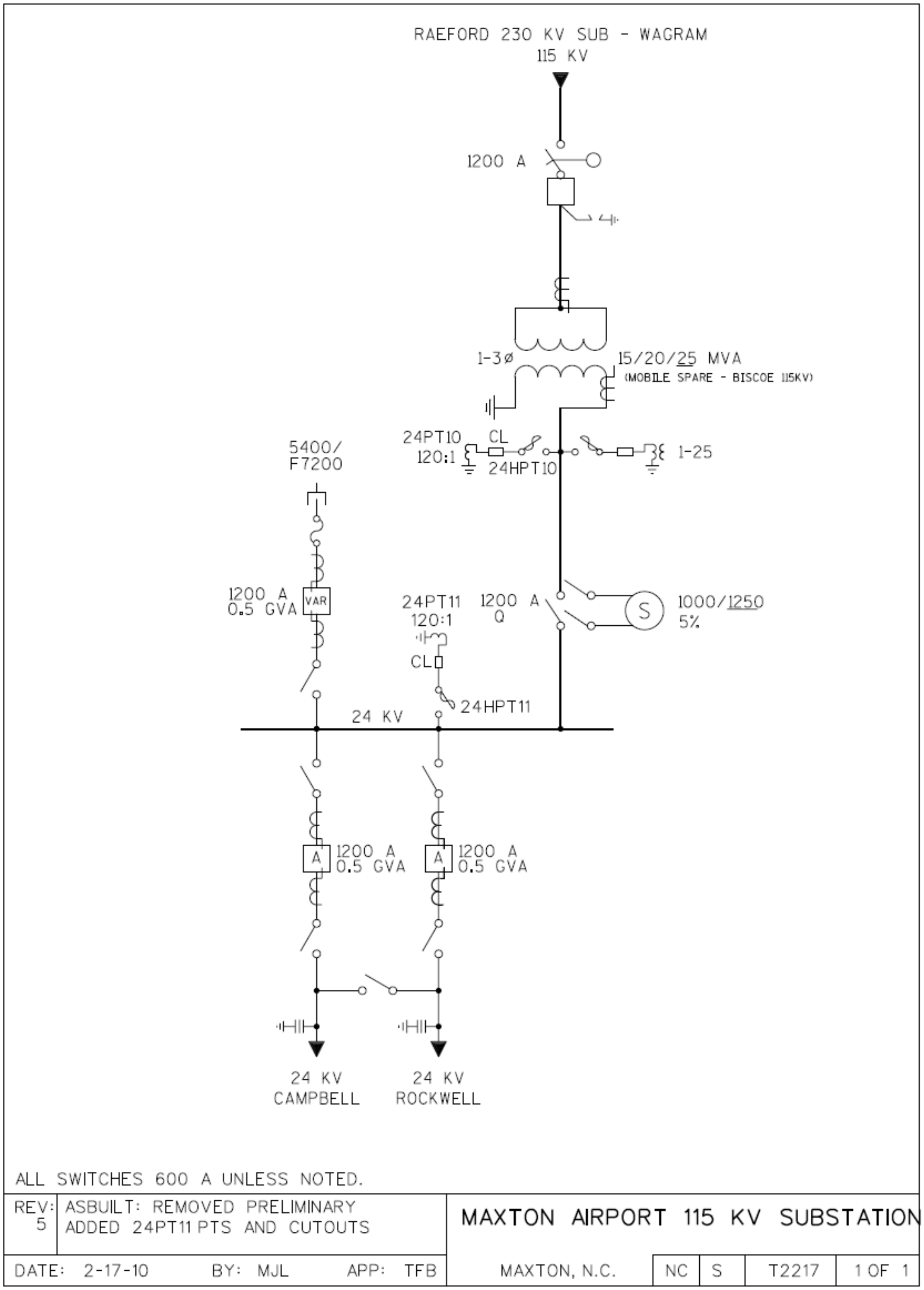


Exhibit 1-10a: local distribution system

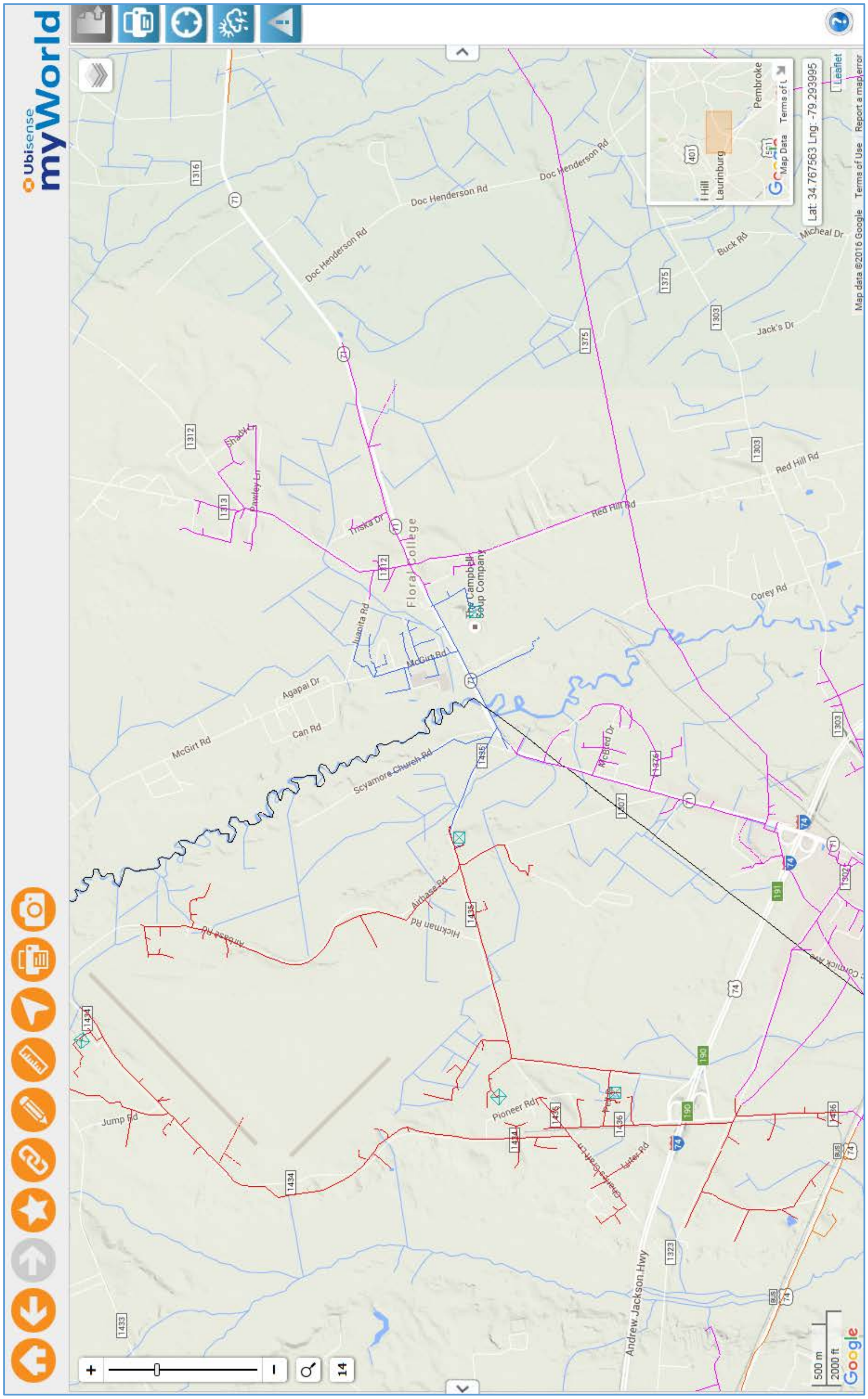


Exhibit 1-10b: local distribution system

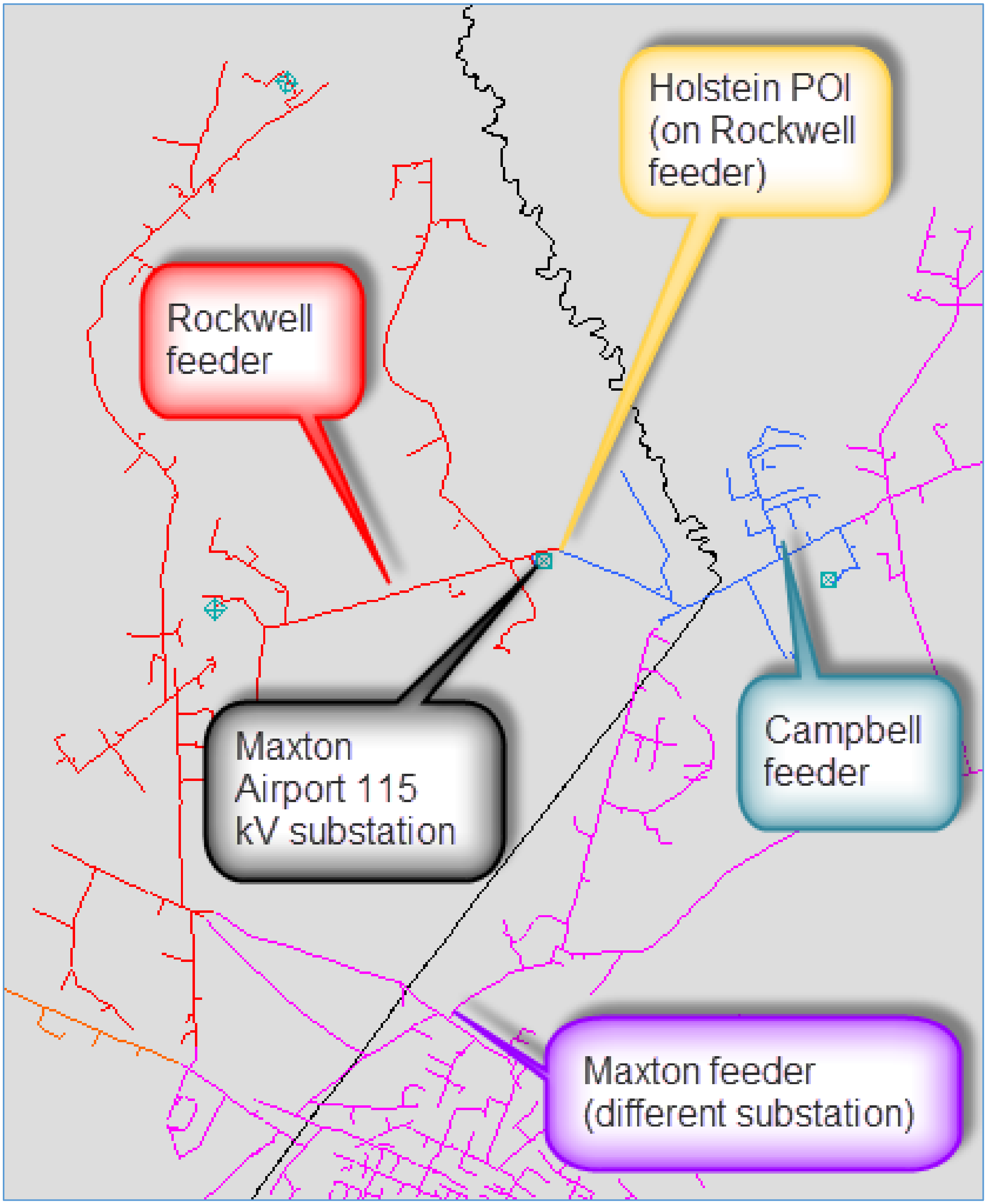
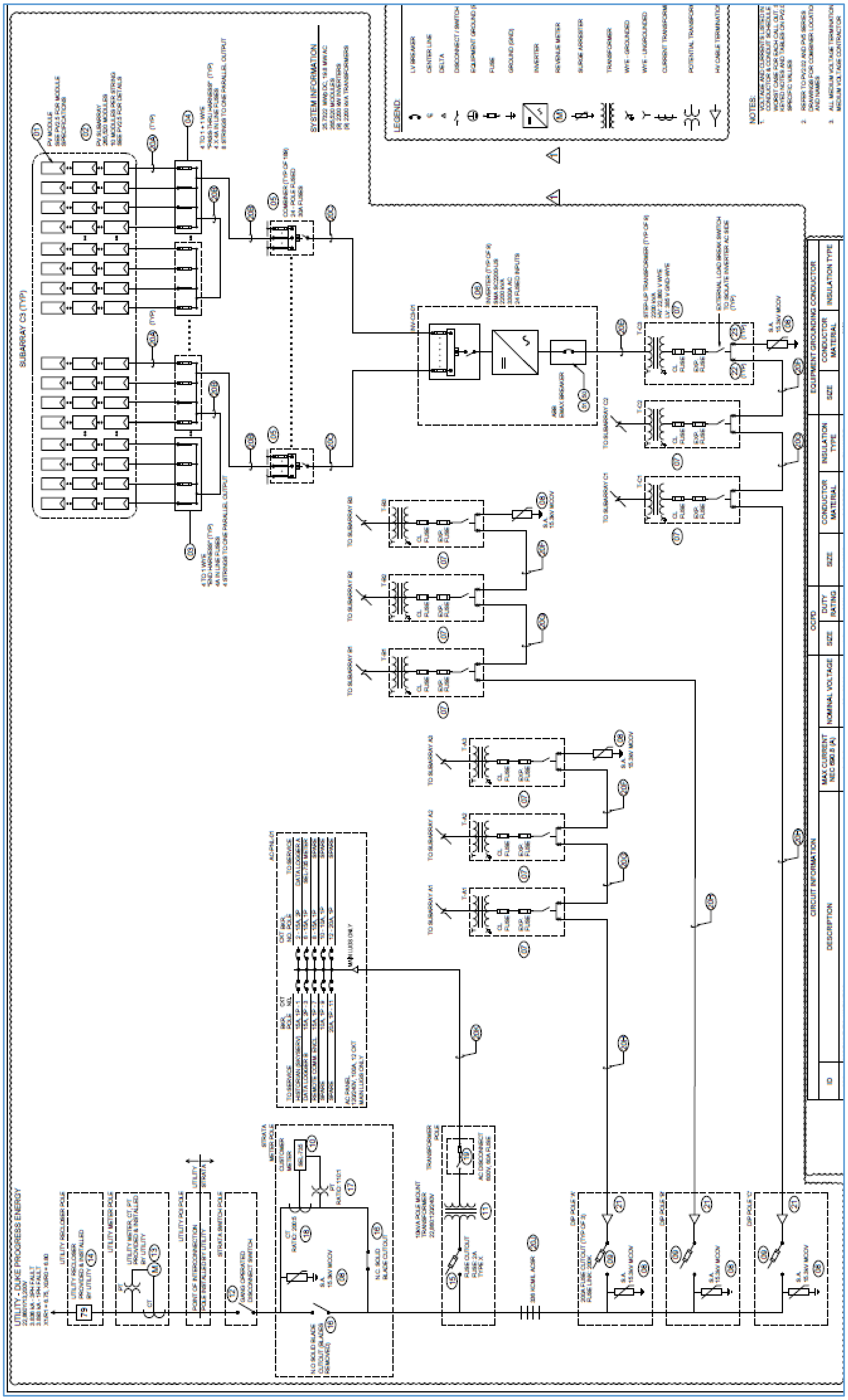


Exhibit 1-11: local distribution system closeup

Exhibit 1-12: Holstein Holdings one-line diagram excerpt



PUBLIC STAFF DATA REQUEST
July 8, 2016

DUKE ENERGY CAROLINAS, LLC AND DUKE ENERGY PROGRESS, LLC
Interconnection process changes

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Questions related to Duke Energy's changes to interconnection study review process to address power quality issues, as presented on June 24, 2016

Power Quality Incident #2: May 2016, 20 MW solar farm, Maxton Airport 115 kV substation

1. Please provide a brief summary of each of the power quality incidents on the DEC and DEP system that have occurred in the past two years that may have involved the addition of distributed generation systems, including the following:
   a. Date of the incident.
      i. May 2, 2016.

   b. Description of the incident, including specific details on any outages or power fluctuations that occurred.
      i. On May 2, 2016, at 19:10:53.912, a three phase fault occurred on the Rockwell 23 kV feeder[1]. The Rockwell feeder breaker relaying at the Maxton Airport 115 kV substation responded appropriately and tripped the Rockwell feeder breaker, resulting in a 17 cycle fault. The relaying and breaker, also per normal operation, reclosed in about 16 cycles, at 19:10:54.462. The breaker remained closed as the fault appeared to have been temporary in nature.

         During the fault and/or during the time the breaker was open, the Duke interconnection recloser (DEP pole ID# 18BR16) at the Strata Solar / Holstein Holdings solar farm tripped open, expectedly, presumably on its own under voltage settings. Once the Rockwell feeder breaker had reclosed, permissive timing logic in the DEP interconnection recloser engaged. This logic, present in generally all DEP interconnection reclosers, starts a three minute timer only after proper nominal voltage and frequency is detected on all three phases on

[1] Data herein is from Duke Energy Progress' FMS (Feeder Monitoring System) equipment, located at the Maxton Airport 115 kV substation. This system consists of PTs at the substation's unregulated and regulated busses, and CTs on at the low side of the transformer and at each feeder breaker.

the utility side of the recloser. At the end of the three minute timer, the recloser closed. FMS (with sensing CTs at the Rockwell feeder breaker) detected the magnetizing inrush event of the Holstein transformers starting at 19:13:54.549. FMS registered the inrush across two logged consecutive events which together lasted approximately 117 cycles (approximately two seconds).

Note Exhibit 2-1, which depicts the phase voltages at the time of the breaker reclose event at 19:10. This can be considered a baseline transformer inrush event; this depicts magnetizing inrush for all transformers on the Rockwell feeder with the exception of the solar farm, and is typical for what is normally seen on Duke Energy Progress feeders at the time of breaker close events.

This is to be compared with the oscillography of the breaker reclose event at 19:13 (note Exhibit 2-2). As is typical for transformer inrush, there was visible harmonic content in the inrush current. However, the inrush event was atypical in its much longer duration and in its significant impact to the harmonic content of the phase voltages as seen at the substation bus.

c. Utility customer that was impacted.
   i. Campbell Soup, which is served from the other feeder (the Campbell feeder) from Maxton Airport 115 kV substation, suffered a process disruption to their industrial process at 19:13 on May 2, 2016.

   Note: Campbell Soup has reported to Duke Energy that they have incurred a total of five events of this nature during the period 1/1/2016 through early May 2016. Duke Energy is currently investigating the other four to see whether or not they are connected to operations at the Holstein Holdings solar farm.

d. Utility equipment, if any, that was impacted.
   i. No utility equipment was noted to have suffered damage.

e. Description of any damage suffered by the utility or its customer(s).
   i. Campbell Soup, which is served from the other feeder (the Campbell feeder) from Maxton Airport 115 kV substation, reported that while they were able to ride through the ~50% voltage sag at the time of the Rockwell feeder fault, they suffered an interruption to their process three minutes after the fault.

   Campbell Soup, which is served from the other feeder (the Campbell feeder) from Maxton Airport 115 kV substation, reported to Duke Energy the next day that they saw both events (the sag at 19:10 and the second transient event at 19:13). They reported that while they were able to ride through the ~50% voltage sag at the time of the Rockwell feeder fault, they suffered an interruption to their process from the 19:13 event. They related that PLCs[2], servos, and VFDs[3] were impacted; these are critical to the operation of their production line and hence they lost product due to this event. It is important to note that while the 19:10 event resulted in voltage sag to ~50% of nominal, the 19:13 event resulted in voltage sag to ~90% of nominal.

Voltage sag metrics would suggest that Campbell should have suffered disruption during the event at 10:10 with more voltage sag. Duke has therefore concluded that the significant harmonic content of the 19:13 event resulted in Campbell's process equipment disruptions.

Duke Energy is not aware of other customer complaints resulting from this event, but it should be noted that many customers do not register power quality complaints due to events that occur within minutes of another interruption.

f. Description of the substation, transformer, and other equipment on the substation or feeder.
   i. See Exhibit 2-3 for a one-line diagram of the Maxton Airport 115 kV substation. This substation is fairly typical of legacy Duke Energy Progress substations. The transformer is a 115 kV – 24 kV, 15 MVA capacity (nominal nameplate rating), with two stages of fans to allow loading at 20 MVA and 25 MVA, respectively. The station is equipped with a three phase bus regulator, and there are two feeder breakers to serve the Campbell 23 kV feeder and the Rockwell 23 kV feeder.

g. Details of the distributed generation systems interconnected on the substation or feeder involved that may have contributed to the incident.
   i. Interconnected at DEP pole ID# 18BR16, the Holstein Holdings solar farm is a 20 MW PV generating facility. See Exhibits 2-4 and 2-5 for the distribution feeder topology that serves the facility. The POI is on the Rockwell feeder, approximately 1000' in electrical distance from the substation.

      See Exhibit 2-6 for an excerpt of the facility's one-line diagram. The facility consists of three grouping of three 2200 kVA transformers, each with an SMA 2200-US inverter, for a total of nine transformers and nine inverters.

[2] Programmable Logic Controller
[3] Variable Frequency Drive

Exhibit 2-1: Phase voltages immediately following breaker reclose at 19:10:54.462.

Exhibit 2-1a: Note breaker close at t=0; note typical harmonic distortion during first 4 cycles of inrush

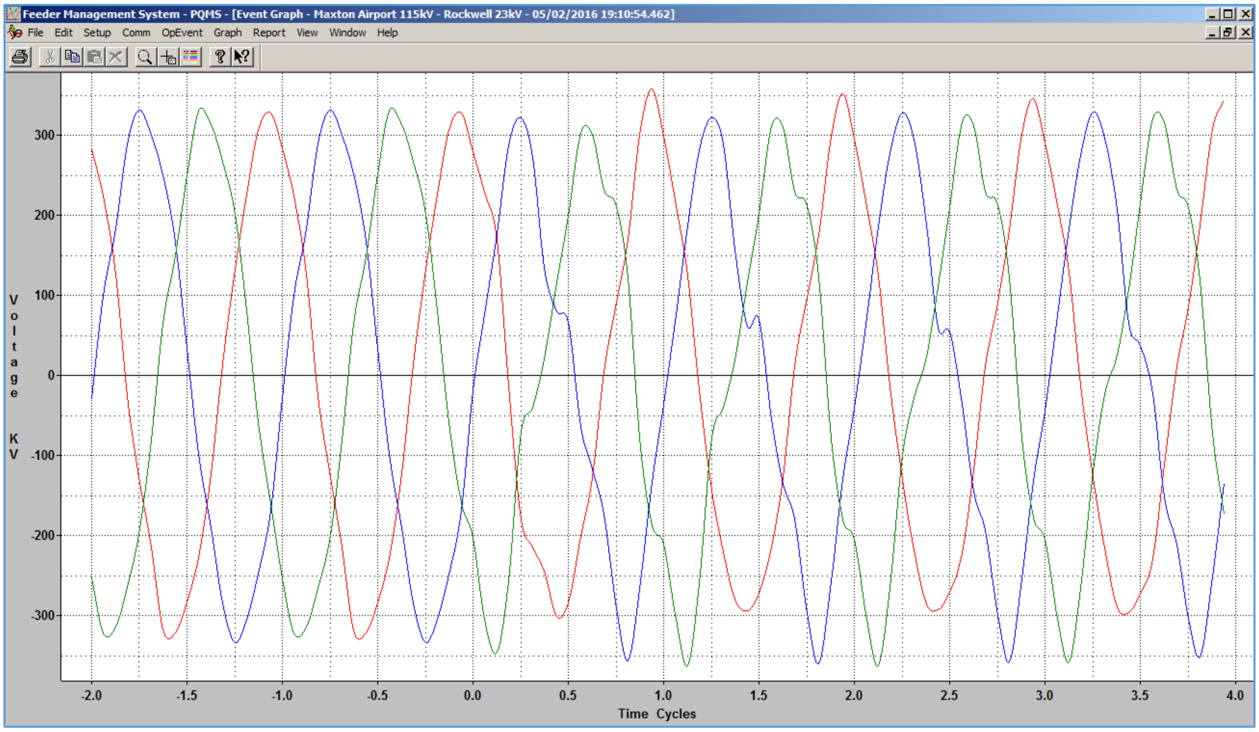


Exhibit 2-1b: Note phase voltages at 31 -- 37 cycles after breaker closing, with diminished harmonic distortion

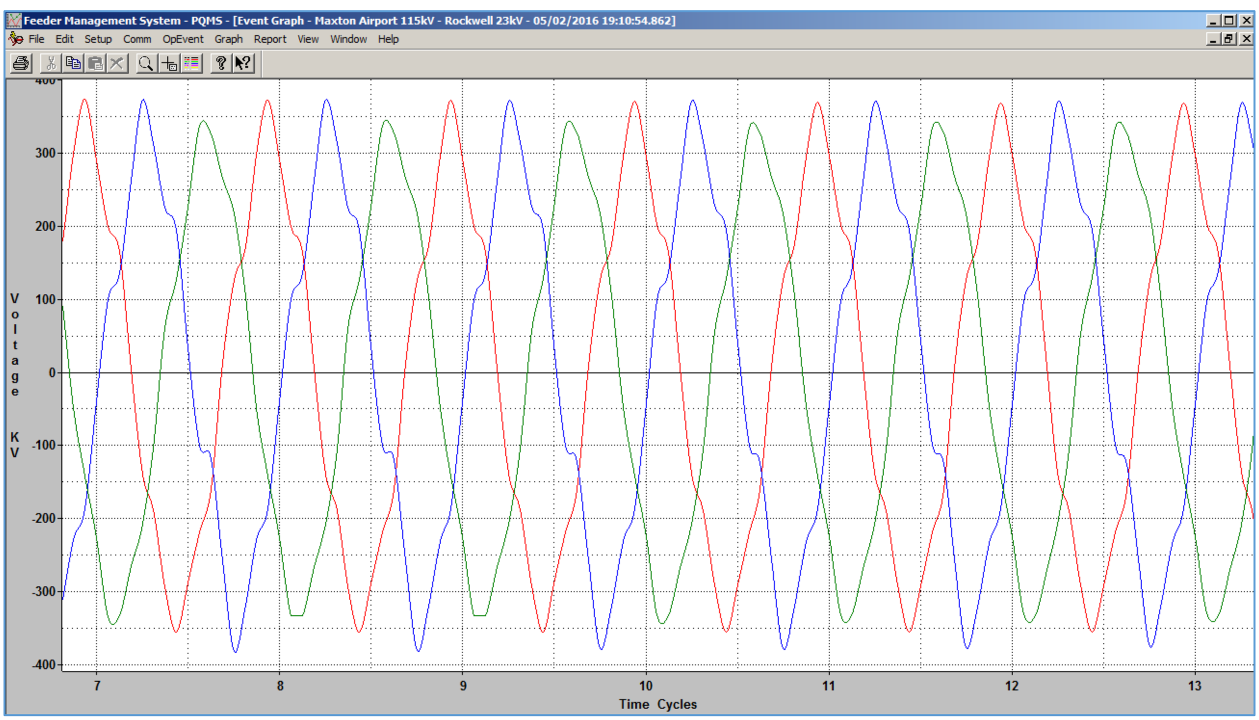


Exhibit 2-2: Phase voltages immediately following interconnection recloser close event at 19:13:54.549.

Exhibit 2-2a: Note recloser closes at t=0; note first 4 cycles of inrush with significant harmonic distortion

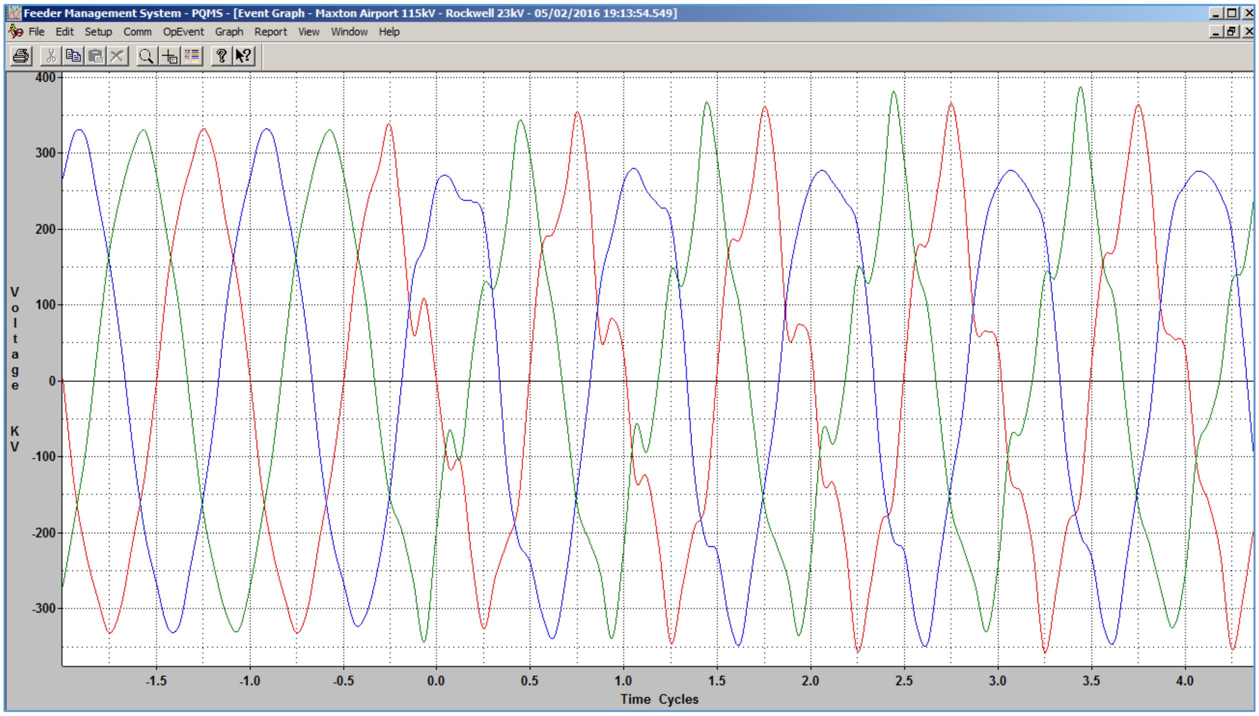


Exhibit 2-2b: Note phase voltages at 31 -- 37 cycles after breaker closing, with sustained and significant harmonic distortion

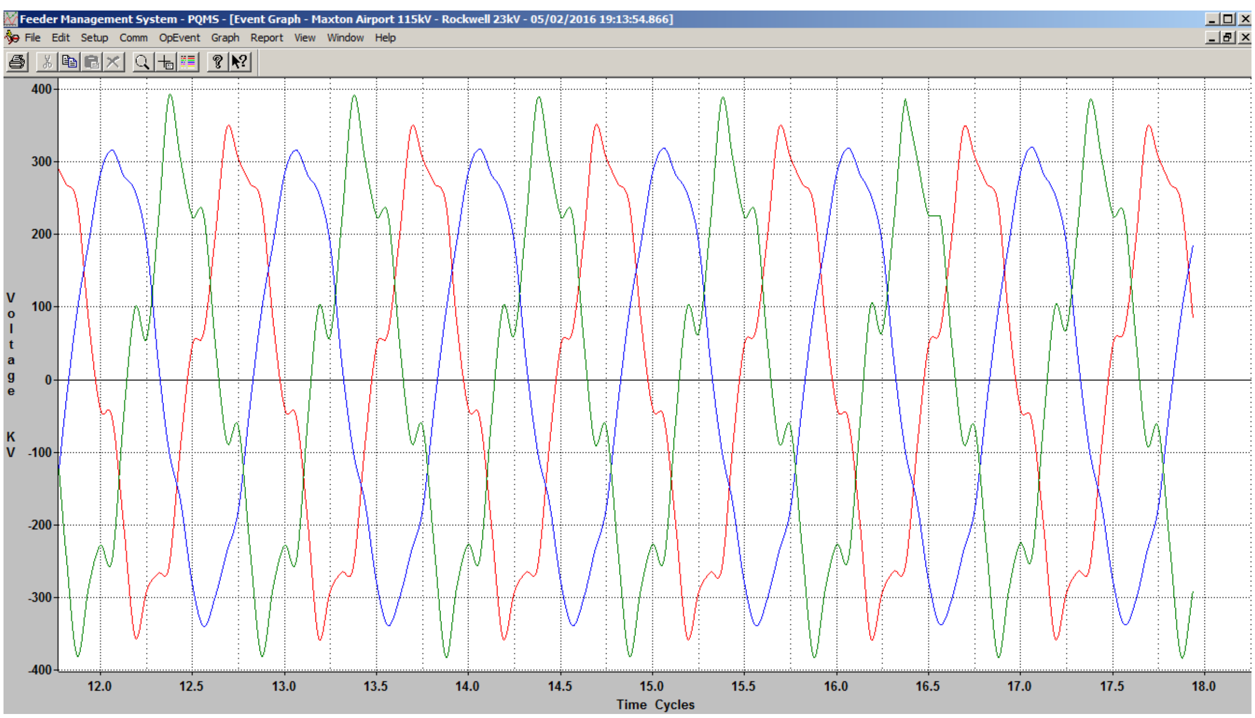


Exhibit 2-3: Maxton Airport 115 kV Substation, one-line diagram

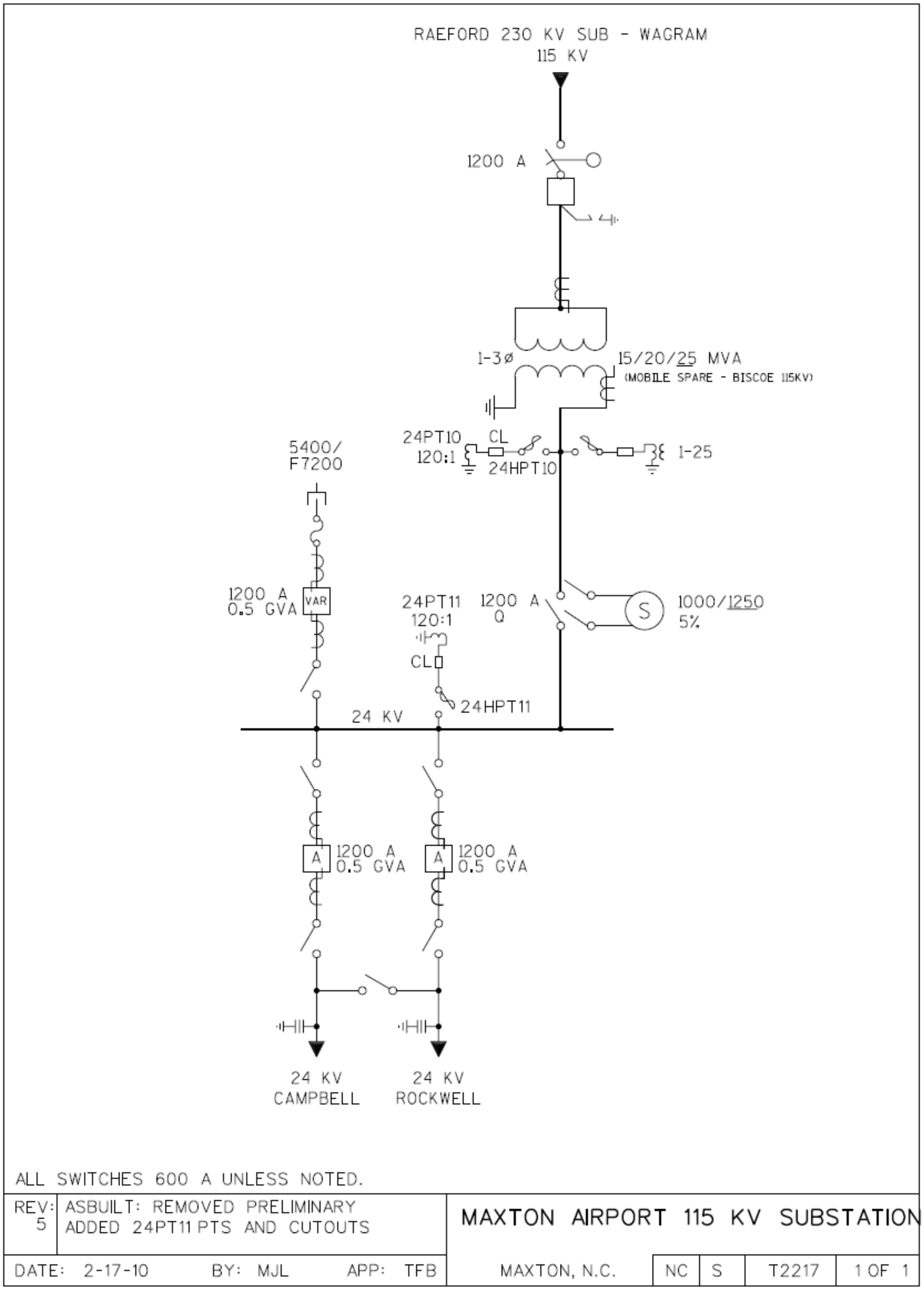


Exhibit 2-4a: local distribution system

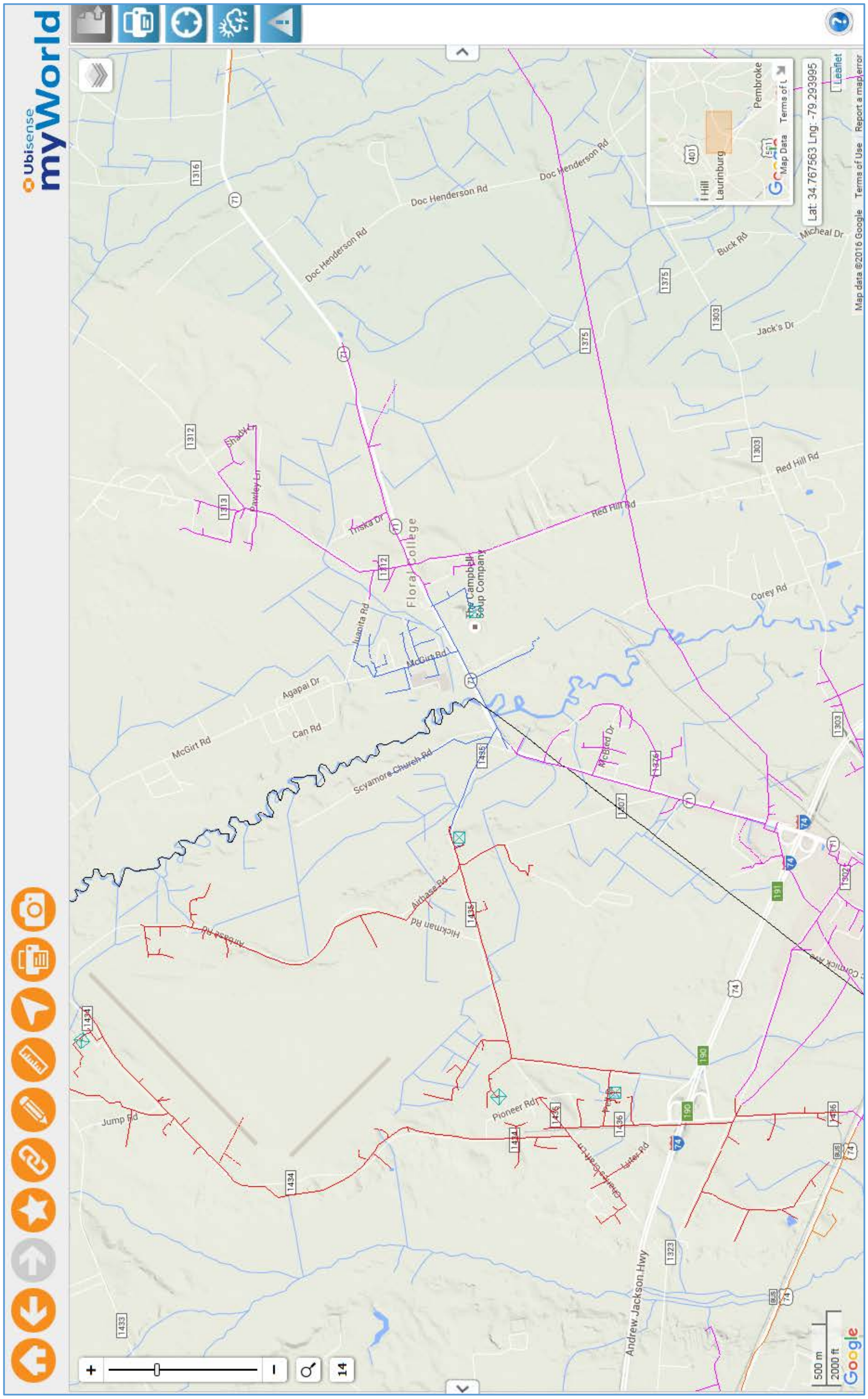


Exhibit 2-4b: local distribution system

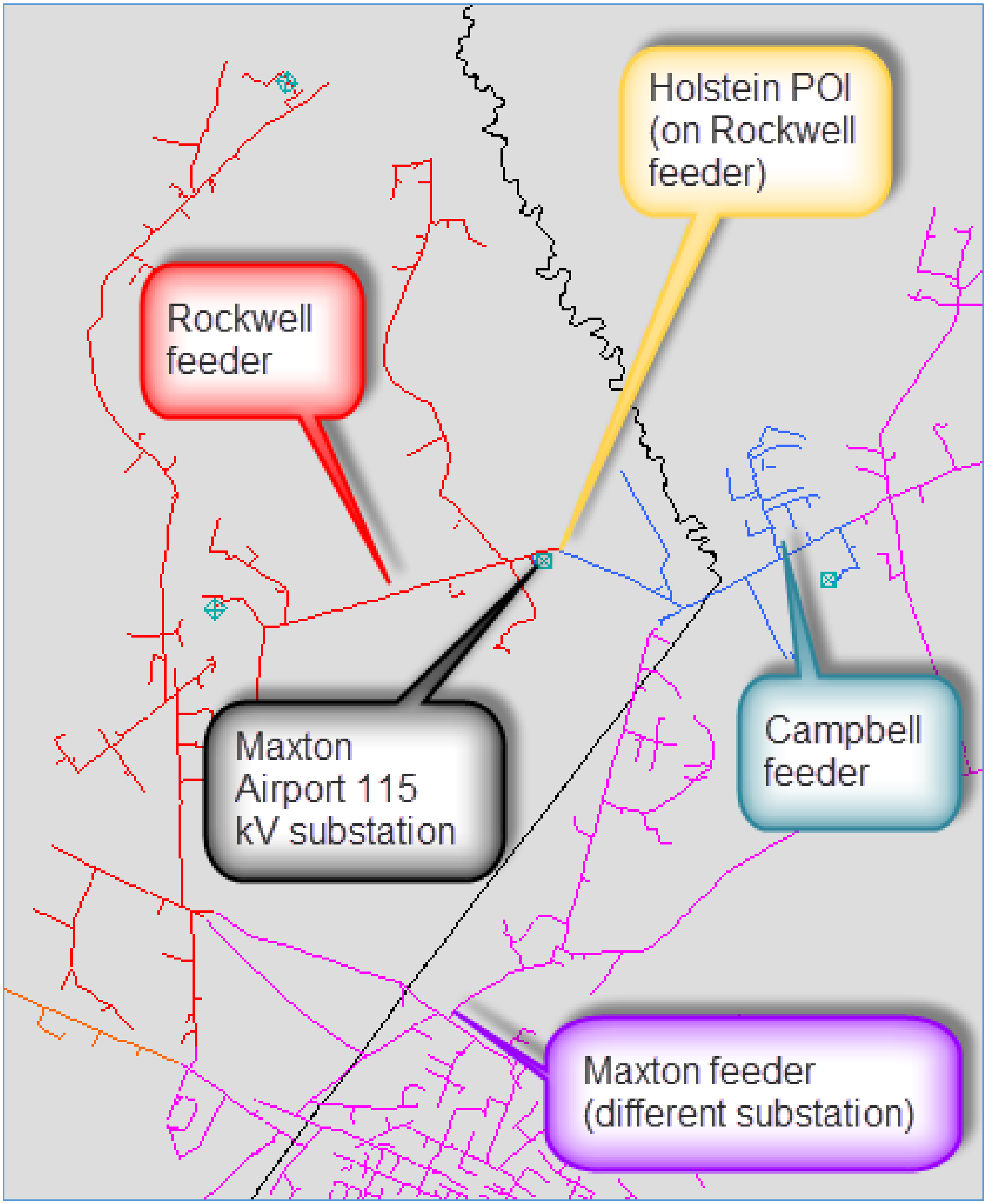
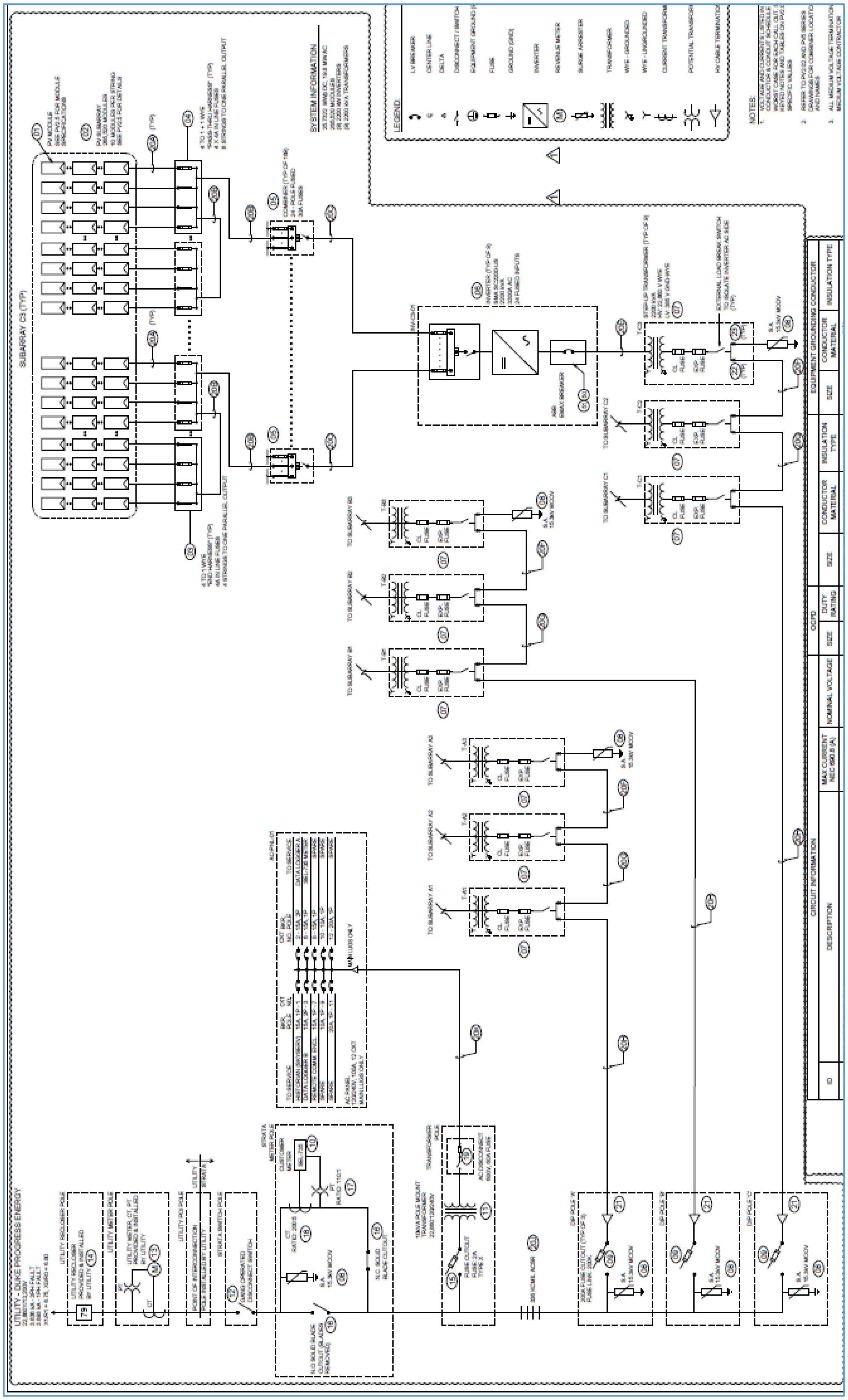


Exhibit 2-5: local distribution system closeup

Exhibit 2-6: Holstein Holdings one-line diagram excerpt



PUBLIC STAFF DATA REQUEST
July 8, 2016

DUKE ENERGY CAROLINAS, LLC AND DUKE ENERGY PROGRESS, LLC
Interconnection process changes

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Questions related to Duke Energy's changes to interconnection study review process to address power quality issues, as presented on June 24, 2016

Power Quality Incident #3: Dec 2014—Mar 2016, two 5 MW solar farms, Elm City 115 kV substation

1. Please provide a brief summary of each of the power quality incidents on the DEC and DEP system that have occurred in the past two years that may have involved the addition of distributed generation systems, including the following:
   a. Date of the incident.
      i. December 2014 – March 2016.

   b. Description of the incident, including specific details on any outages or power fluctuations that occurred.
      i. On December 29, 2014, the Fresh Air XII solar farm appeared to have operated a recloser internal to their facility approximately 60 or more times over a period of time slightly in excess of 3 hours, energizing and de-energizing their transformers each time. A Duke Energy retail customer, Southeastern Diesel Sales (served from the same feeder as the Fresh Air XII and Wilson 1 solar farms) complained due to concerns about their CNC machines and telephone system. Duke Energy's FMS (Feeder Monitoring System) logged a long series of magnetizing inrush events at the Elm City 115 kV substation. Note Exhibit 3-1 which depicts all of the detected events for Dec 1 – Dec 31, 2014, at the Elm City 23 kV feeder circuit breaker.

         After the 12/29/2014 incident, Duke Energy power quality engineers installed power quality meters at Southeastern Diesel, at the Fresh Air XII solar farm POI, and at the Wilson 1 solar farm POI. Southeastern Diesel again saw impacts on January 6, 2015 of additional recloser operations inside the solar farm. Note Exhibit 3-2 which depicts the impacts of these events at Southeastern Diesel.

ii. Further monitoring in the spring of 2016 revealed highly objectionable harmonic response observed at the Fresh Air XII site. This objectionable impact to harmonic voltages near the POI appeared to occur as a response to transformer inrush at the Wilson 1 site (when the utility recloser there was closing in). Note Exhibit 3-3a, in which the voltages and currents at the Fresh Air XII site are shown. This event highlights how the AE500NX inverters at the Fresh Air XII site behaved rather poorly in harmonic response, in comparison to the opposite situation in Exhibit 3-3b where the SMA inverters showed very different behavior. This situation highlights the industry problem with inverters being treated as “black boxes,” with the associated assumptions that all utility compatibility concerns have been addressed through IEEE standards and UL certifications.

c. Utility customer that was impacted.
   i. Southeastern Diesel, located at 5464 U.S. Highway 301N, Elm City, NC 27822.

d. Utility equipment, if any, that was impacted.
   i. No utility equipment was noted to have suffered damage.

e. Description of any damage suffered by the utility or its customer(s).
   i. Southeastern Diesel complained of the disruptive events that occurred in December 2014, but did not cite specific equipment damage.

f. Description of the substation, transformer, and other equipment on the substation or feeder.
   i. See Exhibit 3-4 for a one-line diagram of the Elm City 115 kV substation. The transformer is an arrangement of two paralleled 115 kV – 24 kV, 5 MVA capacity (nominal nameplate rating) transformers (to add to 10 MVA), with one stage of fans to allow loading to 12 MVA. The station is equipped with a three phase bus regulator, and there is one feeder breaker to serve the Elm City 23 kV feeder.

g. Details of the distributed generation systems interconnected on the substation or feeder involved that may have contributed to the incident.
   i. Interconnected at DEP pole ID# 18AN98, the Fresh Air XII solar farm is a 5 MW generating facility, with the POI on the Elm City 23 kV feeder, approximately 600’ in electrical distance from the substation. Interconnected at DEP pole ID# 17QT84, the Wilson 1 solar farm is a 5 MW generating facility, with the POI on the Elm City 23 kV feeder, approximately 6420’ in electrical distance from the substation. See Exhibits 3-5 and 3-6 for the distribution feeder topology that serves the facility.

   ii. See Exhibits 3-7 for excerpts of the facilities’ one-line diagrams.
      1. The Fresh Air XII facility consists of two 1500 kVA transformers and one 2000 kVA transformer, and ten Advanced Energy AE500NX inverters.

2. The Wilson 1 facility consists of ten 500 kVA transformers and ten SMA SC500HE-US inverters.

Exhibit 3-1: Feeder Monitoring System (FMS) overcurrent and under/over voltage event log for Elm City 23 kV feeder breaker, December 2014 (see following 4 pages). Note how the only event in December unrelated to the solar farms was a three phase fault on December 26.

Event Log Report

Event Start	Duration	Outage	Cur A	Cur B	Cur C	Cur N	Volt A	Volt B	Volt C
Elm City 115kV									
Elm City 23kV									
12/26/2014 15:13:06.532	12.0 cycles	No	3320	3725	2882	3238	3%	2%	2%
12/26/2014 15:13:06.741	19.0 cycles	Yes							
12/26/2014 15:13:06.965	91 cycles	No	984		1199	1440	85%		78%
12/26/2014 15:13:08.574	118 cycles	No				69			
12/29/2014 14:42:18.569	5.0 cycles	No				485		96%	
12/29/2014 14:42:18.885	26 cycles	No				27			
12/29/2014 14:42:24.385	10.0 cycles	No		643		556		88%	
12/29/2014 14:42:24.885	26 cycles	No				25			
12/29/2014 14:42:50.826	9.0 cycles	No		777	881	838		84%	82%
12/29/2014 14:42:51.076	62 cycles	No				66			
12/29/2014 14:43:50.244	4.0 cycles	No		655		514		89%	
12/29/2014 14:43:50.477	38 cycles	No				27			
12/29/2014 14:44:42.319	8.0 cycles	No		773		756		86%	104%
12/29/2014 14:44:42.686	50 cycles	No				38			
12/29/2014 14:47:40.987	9.0 cycles	No		719	924	885		86%	80%
12/29/2014 14:47:41.287	62 cycles	No				52			
12/29/2014 14:47:42.504	6.0 cycles	No		513		658		92%	95%
12/29/2014 14:47:42.887	3.0 cycles	No				32			
12/29/2014 14:47:43.021	18.0 cycles	No				30			
12/29/2014 14:47:45.913	10.0 cycles	No		606		846	91%	89%	
12/29/2014 14:47:46.279	26 cycles	No				32			
12/29/2014 14:47:58.712	11.0 cycles	No	699	968	971	1091	86%	80%	79%
12/29/2014 14:47:59.079	63 cycles	No				52			
12/29/2014 14:48:01.870	10.0 cycles	No		575		623		90%	91%
12/29/2014 14:48:02.287	26 cycles	No				37			
12/29/2014 14:48:18.837	10.0 cycles	No		781	639	746		85%	89%
12/29/2014 14:48:19.287	38 cycles	No				37			
12/29/2014 14:48:32.221	10.0 cycles	No		887	835	836		82%	84%
12/29/2014 14:48:32.488	101 cycles	No		637	826	864	91%	90%	84%
12/29/2014 14:48:34.255	4.0 cycles	No				97			
12/29/2014 14:49:04.179	4.0 cycles	No				424			
12/29/2014 14:49:04.279	27 cycles	No				51			
12/29/2014 14:49:05.879	15.0 cycles	No				25			
12/29/2014 14:49:07.487	14.0 cycles	No				29			
12/29/2014 14:49:08.488	14.0 cycles	No				42			
12/29/2014 14:49:08.838	3.0 cycles	No				434			
12/29/2014 14:49:09.088	26 cycles	No				44			
12/29/2014 14:49:11.088	14.0 cycles	No				33			
12/29/2014 14:49:15.354	3.0 cycles	No				430			
12/29/2014 14:49:15.688	14.0 cycles	No				30			
12/29/2014 14:49:16.488	14.0 cycles	No				35			
12/29/2014 14:49:24.505	4.0 cycles	No				494			
12/29/2014 14:49:24.889	14.0 cycles	No				27			
12/29/2014 14:49:32.971	3.0 cycles	No				426			
12/29/2014 14:49:33.288	14.0 cycles	No				32			
12/29/2014 14:49:36.338	3.0 cycles	No				431			
12/29/2014 14:49:36.688	14.0 cycles	No				31			
12/29/2014 14:49:45.621	3.0 cycles	No				425			
12/29/2014 14:49:45.888	14.0 cycles	No				31			
12/29/2014 14:49:58.046	4.0 cycles	No				431			
12/29/2014 14:49:58.479	15.0 cycles	No				30			
12/29/2014 14:50:01.079	15.0 cycles	No				28			
12/29/2014 14:50:10.529	3.0 cycles	No				434			
12/29/2014 14:50:10.679	27 cycles	No				146			

Event Log Report

Event Start	Duration	Outage	Cur A	Cur B	Cur C	Cur N	Volt A	Volt B	Volt C
12/29/2014 14:50:27.055	4.0 cycles	No				431			
12/29/2014 14:50:27.488	14.0 cycles	No				41			
12/29/2014 14:50:29.297	4.0 cycles	No				504			
12/29/2014 14:50:29.680	15.0 cycles	No				85			
12/29/2014 14:50:58.696	3.0 cycles	No				422			
12/29/2014 14:50:59.080	15.0 cycles	No				144			
12/29/2014 14:51:00.080	15.0 cycles	No				74			
12/29/2014 14:51:00.579	3.0 cycles	No				480			
12/29/2014 14:51:00.880	15.0 cycles	No				28			
12/29/2014 14:51:05.896	4.0 cycles	No				466			
12/29/2014 14:51:06.280	15.0 cycles	No				39			
12/29/2014 14:51:54.978	3.0 cycles	No				430			
12/29/2014 14:51:55.262	15.0 cycles	No				25			
12/29/2014 14:54:21.568	3.0 cycles	No				332			
12/29/2014 14:54:21.852	14.0 cycles	No				58			
12/29/2014 15:20:38.942	9.0 cycles	No	996	947		945	79%	82%	
12/29/2014 15:20:39.226	38 cycles	No				57			
12/29/2014 15:20:42.683	8.0 cycles	No		685	586	739	94%	87%	91%
12/29/2014 15:20:45.426	6.0 cycles	No				678		103%	
12/29/2014 15:20:45.809	15.0 cycles	No				38			
12/29/2014 15:20:49.125	10.0 cycles	No	715	804		777	87%	84%	93%
12/29/2014 15:20:56.133	10.0 cycles	No		717	794	825		87%	86%
12/29/2014 15:20:56.417	50 cycles	No				41			
12/29/2014 15:20:58.317	10.0 cycles	No		624	607	752	91%	89%	90%
12/29/2014 15:20:58.616	50 cycles	No				46			
12/29/2014 15:21:07.733	10.0 cycles	No		748	808	839		87%	85%
12/29/2014 15:21:08.017	50 cycles	No				44			
12/29/2014 15:21:10.809	8.0 cycles	No	590	783		760	90%	86%	
12/29/2014 15:21:11.226	31 cycles	No				35			
12/29/2014 15:21:17.058	4.0 cycles	No	778	659		857	85%	87%	
12/29/2014 15:21:17.425	14.0 cycles	No				32			
12/29/2014 15:21:29.476	11.0 cycles	No		1007	1015	1135	91%	81%	79%
12/29/2014 15:21:29.826	62 cycles	No				56			
12/29/2014 15:21:50.892	8.0 cycles	No				682		93%	
12/29/2014 15:21:51.226	26 cycles	No				27			
12/29/2014 15:21:51.942	3.0 cycles	No					89%		
12/29/2014 15:21:52.226	37 cycles	No				245			
12/29/2014 15:21:52.926	8.0 cycles	No				37			
12/29/2014 17:43:38.538	7.0 cycles	No				720	91%	92%	
12/29/2014 17:43:38.805	26 cycles	No				27			
12/29/2014 17:43:41.277	10.0 cycles	No	836	709		885	82%	88%	
12/29/2014 17:43:41.593	27 cycles	No				33			
12/29/2014 17:43:43.823	10.0 cycles	No		724	711	809		87%	88%
12/29/2014 17:43:44.190	39 cycles	No				38			
12/29/2014 17:43:47.662	8.0 cycles	No		624	664	829		90%	92%
12/29/2014 17:43:50.865	6.0 cycles	No				640		95%	
12/29/2014 17:43:51.182	27 cycles	No				28			
12/29/2014 17:43:55.366	7.0 cycles	No			566	767			93%
12/29/2014 17:43:55.783	14.0 cycles	No				30			
12/29/2014 17:44:00.611	9.0 cycles	No	617	803		749	91%	88%	94%
12/29/2014 17:44:00.977	38 cycles	No				34			
12/29/2014 17:44:03.569	7.0 cycles	No			574	789			92%
12/29/2014 17:44:03.970	27 cycles	No				39			
12/29/2014 17:44:06.886	6.0 cycles	No			503	691		96%	93%
12/29/2014 17:44:07.169	24 cycles	No				36			
12/29/2014 17:46:52.470	6.0 cycles	No	799	646		781	86%	89%	
12/29/2014 17:46:52.770	27 cycles	No				45			

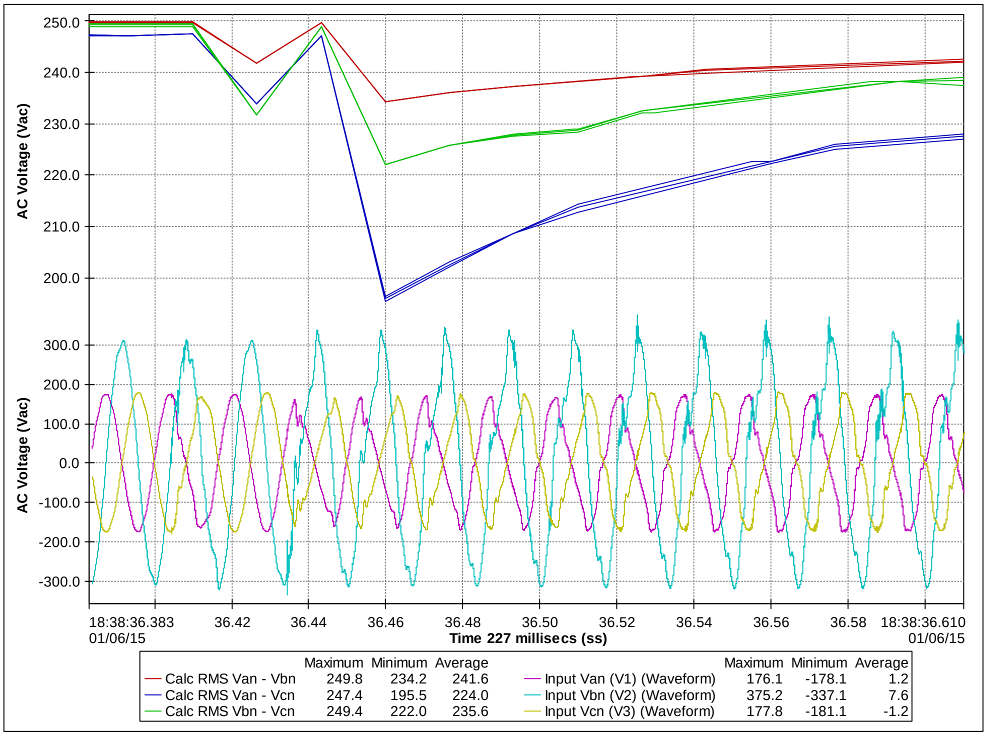
Event Log Report

Event Start	Duration	Outage	Cur A	Cur B	Cur C	Cur N	Volt A	Volt B	Volt C
12/29/2014 17:46:53.870	4.0 cycles	No	766	640		808	86%	91%	
12/29/2014 17:46:54.170	15.0 cycles	No				26			
12/29/2014 17:46:54.513	6.0 cycles	No				24			
12/29/2014 17:47:39.217	9.0 cycles	No			556	688	87%		92%
12/29/2014 17:47:39.534	39 cycles	No				35			
12/29/2014 17:47:46.649	9.0 cycles	No		609	733	754		91%	89%
12/29/2014 17:47:46.933	38 cycles	No				41			
12/29/2014 17:47:51.818	5.0 cycles	No			602	751			95%
12/29/2014 17:47:52.118	27 cycles	No				30			
12/29/2014 17:48:03.416	6.0 cycles	No		1015	694	817		83%	89%
12/29/2014 17:48:03.716	26 cycles	No				29			
12/29/2014 17:48:04.733	8.0 cycles	No	727	676	579	795	86%	89%	92%
12/29/2014 17:48:05.099	16.0 cycles	No				31			
12/29/2014 17:48:05.459	5.0 cycles	No				29			
12/29/2014 17:48:06.275	10.0 cycles	No		707	718	800		89%	87%
12/29/2014 17:48:06.709	39 cycles	No				43			
12/29/2014 17:48:09.450	2.0 cycles	No		668		683		93%	94%
12/29/2014 17:48:12.258	8.0 cycles	No				631	90%		92%
12/29/2014 17:48:12.708	15.0 cycles	No				35			
12/29/2014 17:48:19.508	8.0 cycles	No		574	647	853		91%	91%
12/29/2014 17:48:19.908	26 cycles	No				34			
12/29/2014 17:48:26.850	9.0 cycles	No		772	605	838		87%	91%
12/29/2014 17:48:27.117	38 cycles	No				49			
12/29/2014 17:48:49.100	4.0 cycles	No	677			605	87%		
12/29/2014 17:48:49.500	15.0 cycles	No				29			
12/29/2014 17:48:58.967	4.0 cycles	No	791	639		848	85%	96%	
12/29/2014 17:48:59.317	14.0 cycles	No				35			
12/29/2014 17:49:33.296	4.0 cycles	No	814			881	86%		
12/29/2014 17:49:33.713	14.0 cycles	No				27			
12/29/2014 17:49:37.857	3.0 cycles	No				465			
12/29/2014 17:49:38.307	14.0 cycles	No				25			
12/29/2014 17:49:43.059	8.0 cycles	No			826	729	104%		93%
12/29/2014 17:49:43.492	15.0 cycles	No				31			
12/29/2014 17:49:51.590	5.0 cycles	No				575	104%		
12/29/2014 17:49:51.890	26 cycles	No				25			
12/29/2014 17:50:01.603	7.0 cycles	No	757			672	86%		
12/29/2014 17:50:01.870	27 cycles	No				29			
12/29/2014 17:50:03.220	3.0 cycles	No				25			
12/29/2014 17:50:03.470	5.0 cycles	No				29			
12/29/2014 17:50:03.651	16.0 cycles	No				28			
12/29/2014 17:50:28.925	10.0 cycles	No		637	708	914		88%	88%
12/29/2014 17:50:29.259	39 cycles	No				35			
12/29/2014 17:50:34.959	11.0 cycles	No		605	669	881		91%	91%
12/29/2014 17:50:35.259	27 cycles	No				32			
12/29/2014 17:50:46.400	9.0 cycles	No	495	906		837	92%	83%	
12/29/2014 17:50:46.667	26 cycles	No				27			
12/29/2014 17:50:50.558	9.0 cycles	No			616	813			89%
12/29/2014 17:50:50.858	27 cycles	No				38			
12/29/2014 17:51:25.326	4.0 cycles	No				661			
12/29/2014 17:51:25.643	26 cycles	No				27			
12/29/2014 17:51:26.810	10.0 cycles	No		693	747	879		88%	87%
12/29/2014 17:51:27.243	2.0 cycles	No				49			
12/29/2014 17:51:27.376	42 cycles	No				45			
12/29/2014 17:51:31.626	9.0 cycles	No		709		840		89%	
12/29/2014 17:51:32.043	26 cycles	No				36			
12/29/2014 17:51:34.642	26 cycles	No				26			
12/29/2014 17:51:37.067	9.0 cycles	No		529	689	730	96%	91%	91%

Event Log Report

Event Start	Duration	Outage	Cur A	Cur B	Cur C	Cur N	Volt A	Volt B	Volt C
12/29/2014 17:51:37.434	26 cycles	No				33			
12/29/2014 17:51:46.826	5.0 cycles	No				711	92%	89%	
12/29/2014 17:51:47.226	15.0 cycles	No				24			
12/29/2014 17:51:48.376	6.0 cycles	No	591			599	96%	95%	
12/29/2014 17:51:48.643	8.0 cycles	No				38			
12/29/2014 17:51:48.868	24 cycles	No				33			
12/29/2014 17:51:49.834	26 cycles	No				28			
12/29/2014 17:51:50.701	4.0 cycles	No				571			
12/29/2014 17:51:51.842	10.0 cycles	No		891	920	918		84%	84%
12/29/2014 17:51:52.242	38 cycles	No				39			
12/29/2014 17:51:53.625	10.0 cycles	No				24			
12/30/2014 11:42:31.876	9.0 cycles	No	709	701		774	89%	89%	
12/30/2014 11:42:32.276	62 cycles	No				328			
12/31/2014 08:54:41.665	6.0 cycles	No				777	95%	88%	
12/31/2014 08:54:42.032	95 cycles	No				245			
12/31/2014 08:54:44.023	15.0 cycles	No				134			
12/31/2014 08:54:44.840	38 cycles	No				210			
12/31/2014 08:54:45.640	2.0 cycles	No				77			
12/31/2014 09:40:05.823	4.0 cycles	No				602	88%		
12/31/2014 09:40:06.240	92 cycles	No				144			
12/31/2014 09:40:07.866	118 cycles	No				228			
12/31/2014 09:50:34.451	8.0 cycles	No			586	445			90%
12/31/2014 09:50:34.851	26 cycles	No				141			

Exhibit 3-2: Detected events at customer site in early January 2015 (Southeastern Diesel).



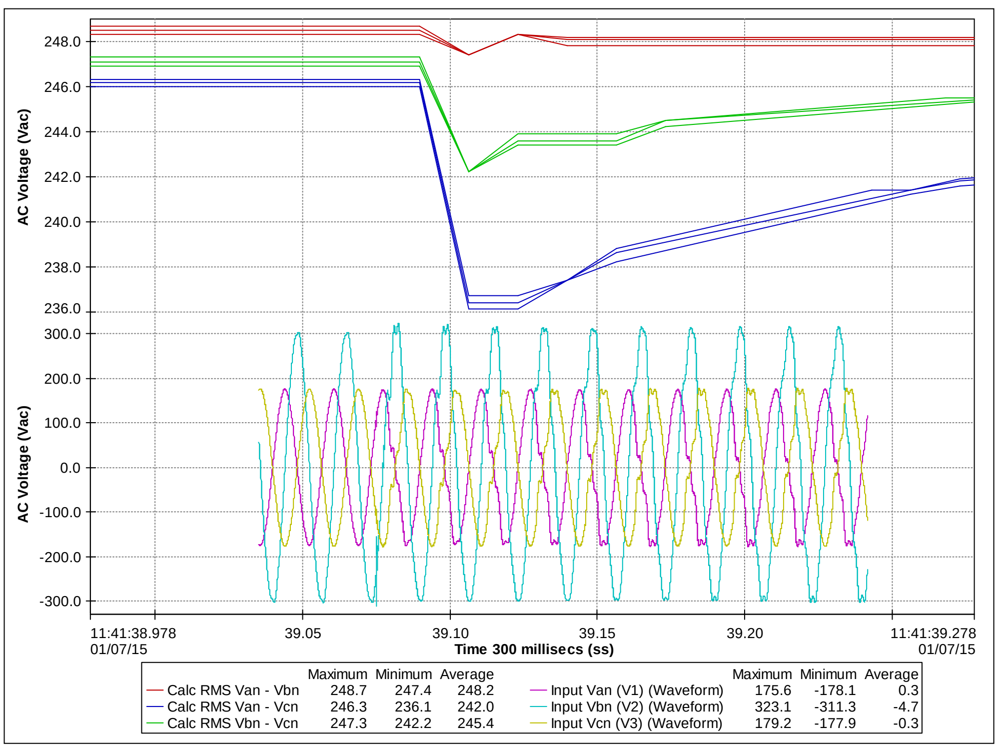
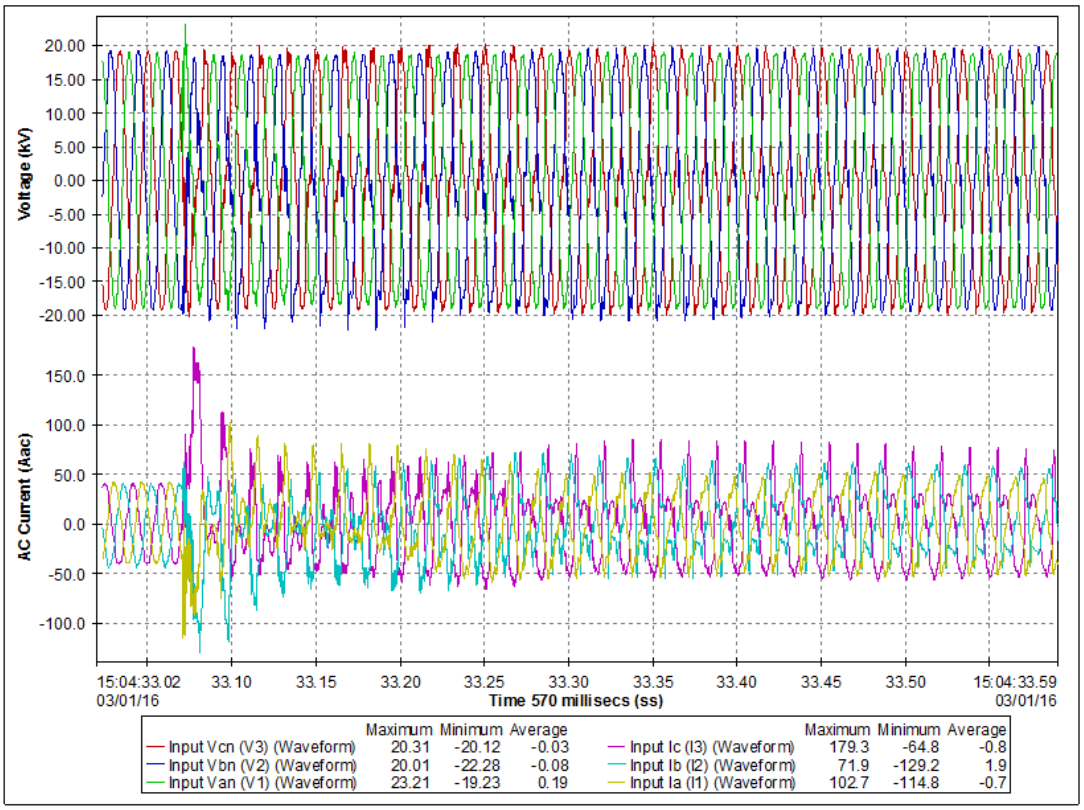


Exhibit 3-3a: Harmonic voltage and current response at the Fresh Air XII site POI, to magnetizing inrush at the Wilson 1 site. Note the excessive harmonic distortion in voltages and currents at the Fresh Air XII POI.

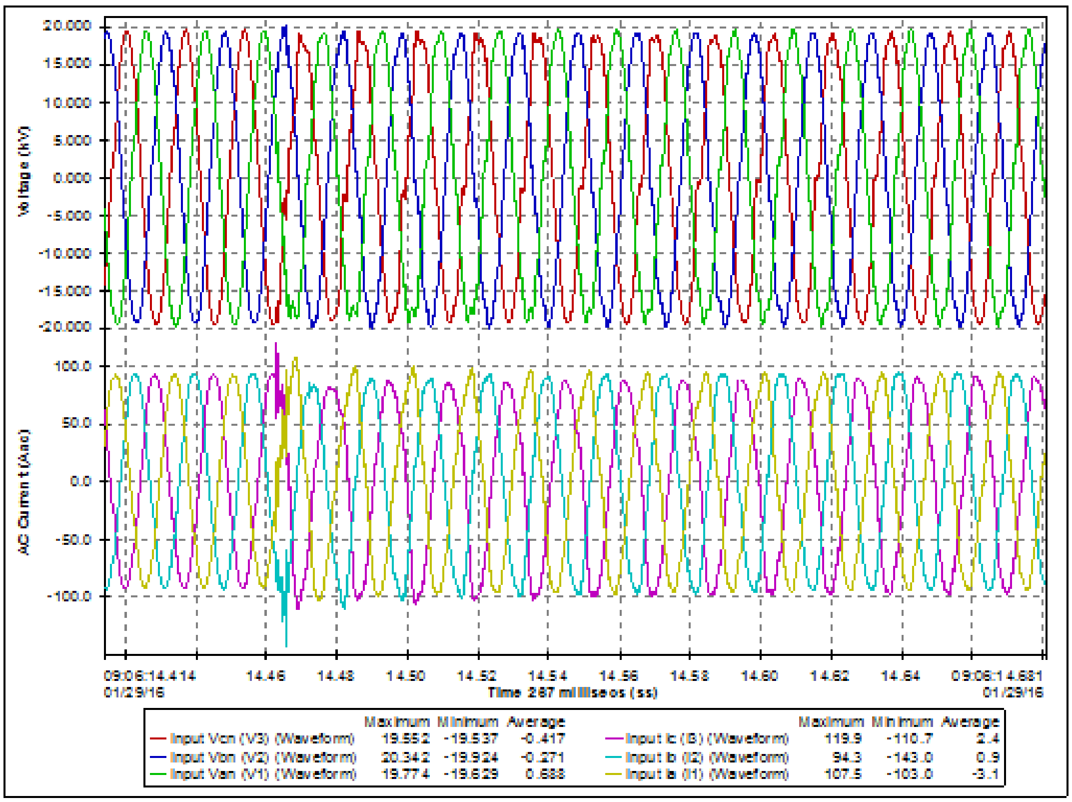
Fresh Air Energy XII DIS # 18AN98



Inverter response at Fresh Air site to transformer inrush from Wilson site

Exhibit 3-3b: Harmonic voltage and current response at the Wilson 1 site POI, to inrush from the Fresh Air XII site connecting to the system. Note that there was little harmonic distortion associated with the inrush contribution seen at the Wilson 1 POI.

Wilson Solar Farm I DIS # 17QT84



Inverter response at this site to transformer inrush from other solar farm.

Exhibit 3-4: Elm City 115 kV Substation, one-line diagram

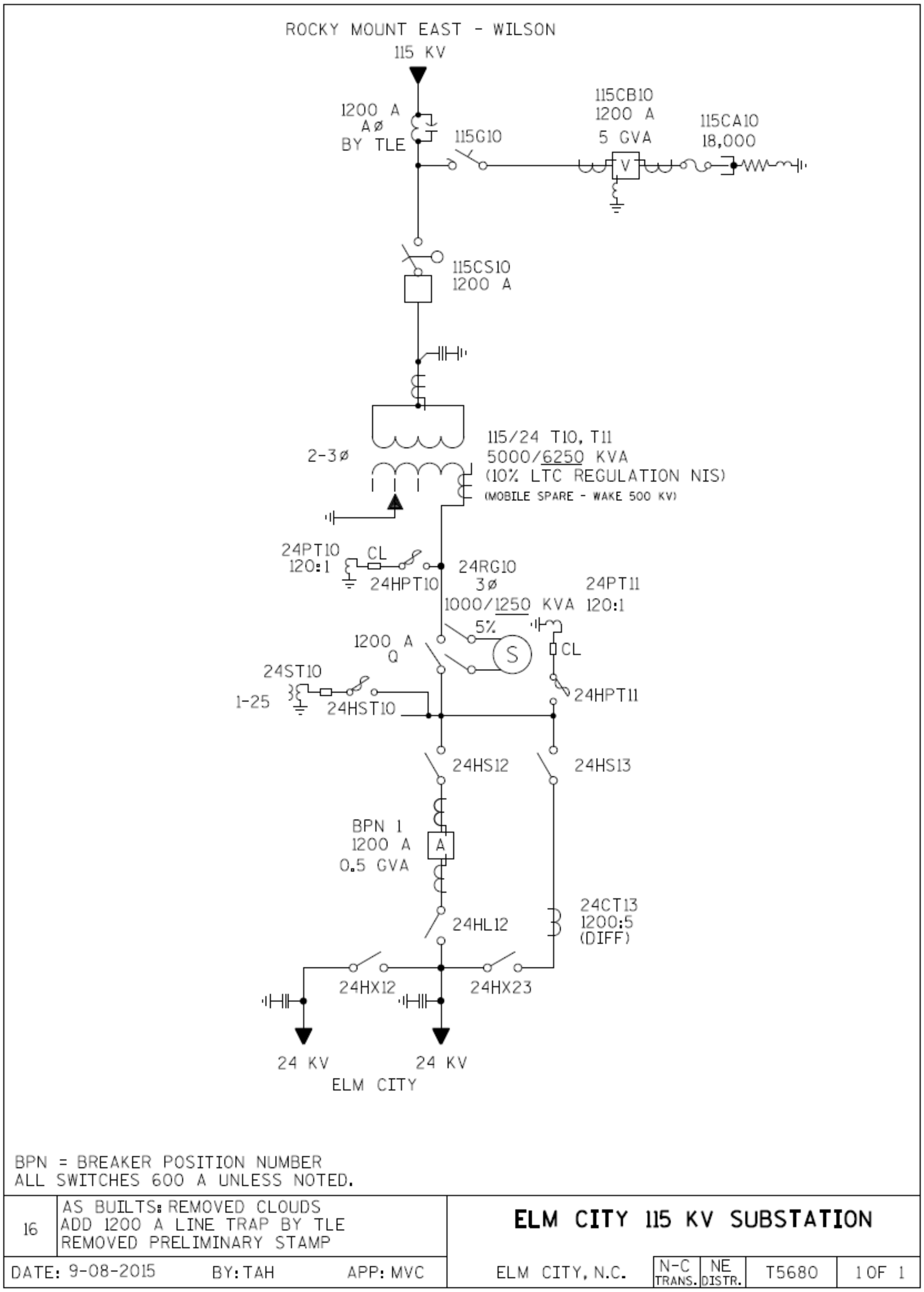


Exhibit 3-5a: local distribution system

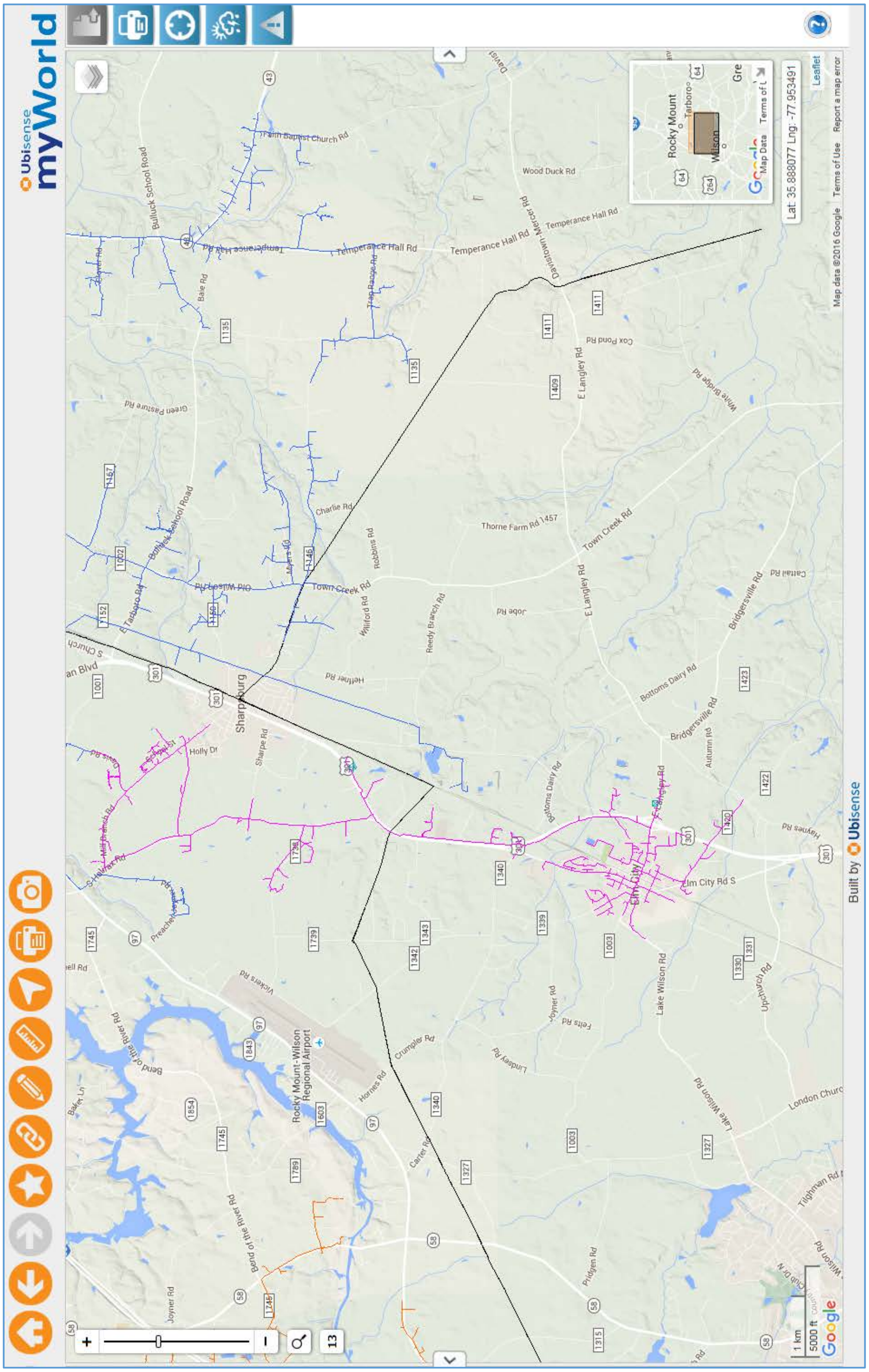


Exhibit 3-5b: local distribution system

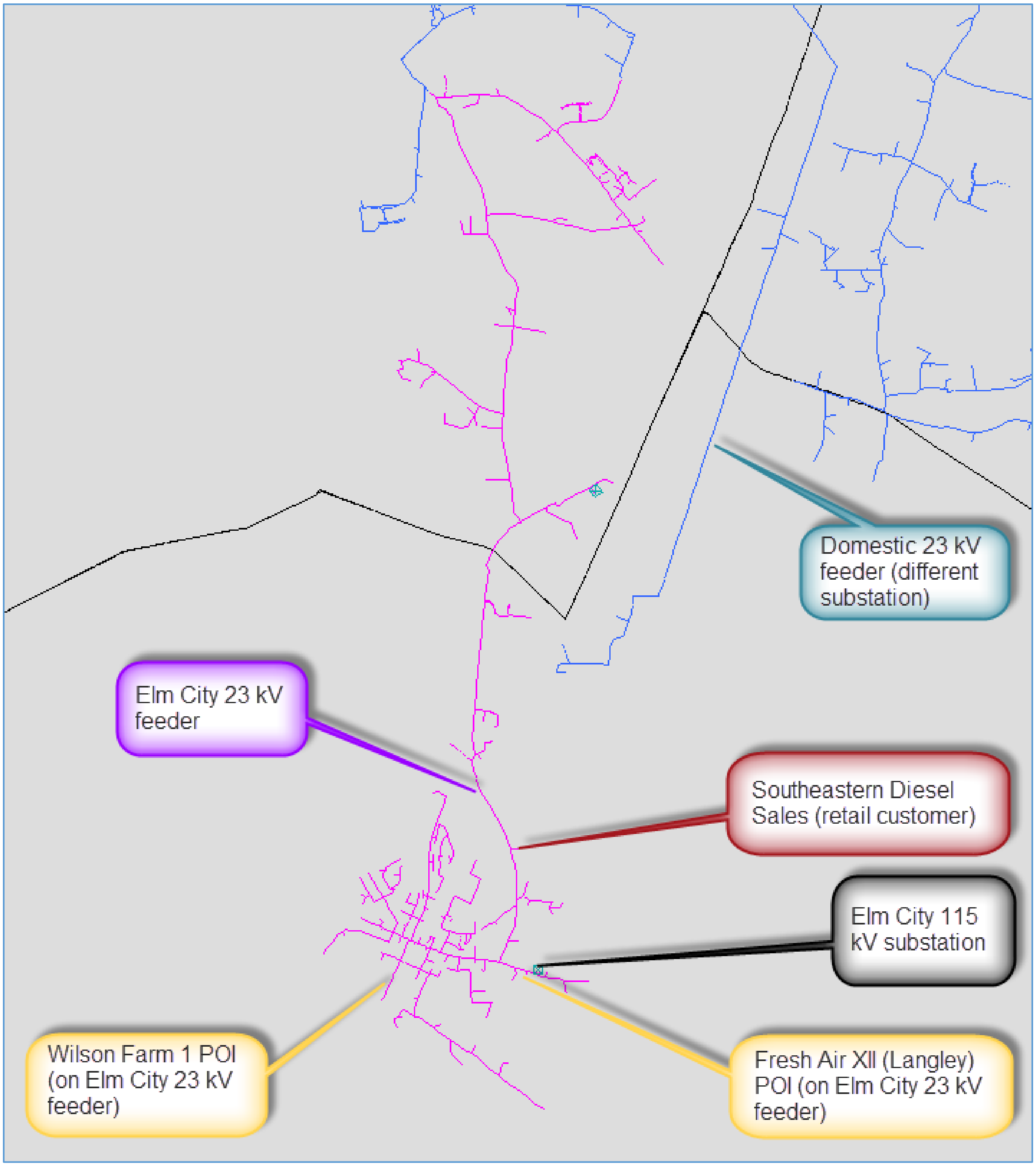


Exhibit 3-6a: local distribution system closeup, Fresh Air XII

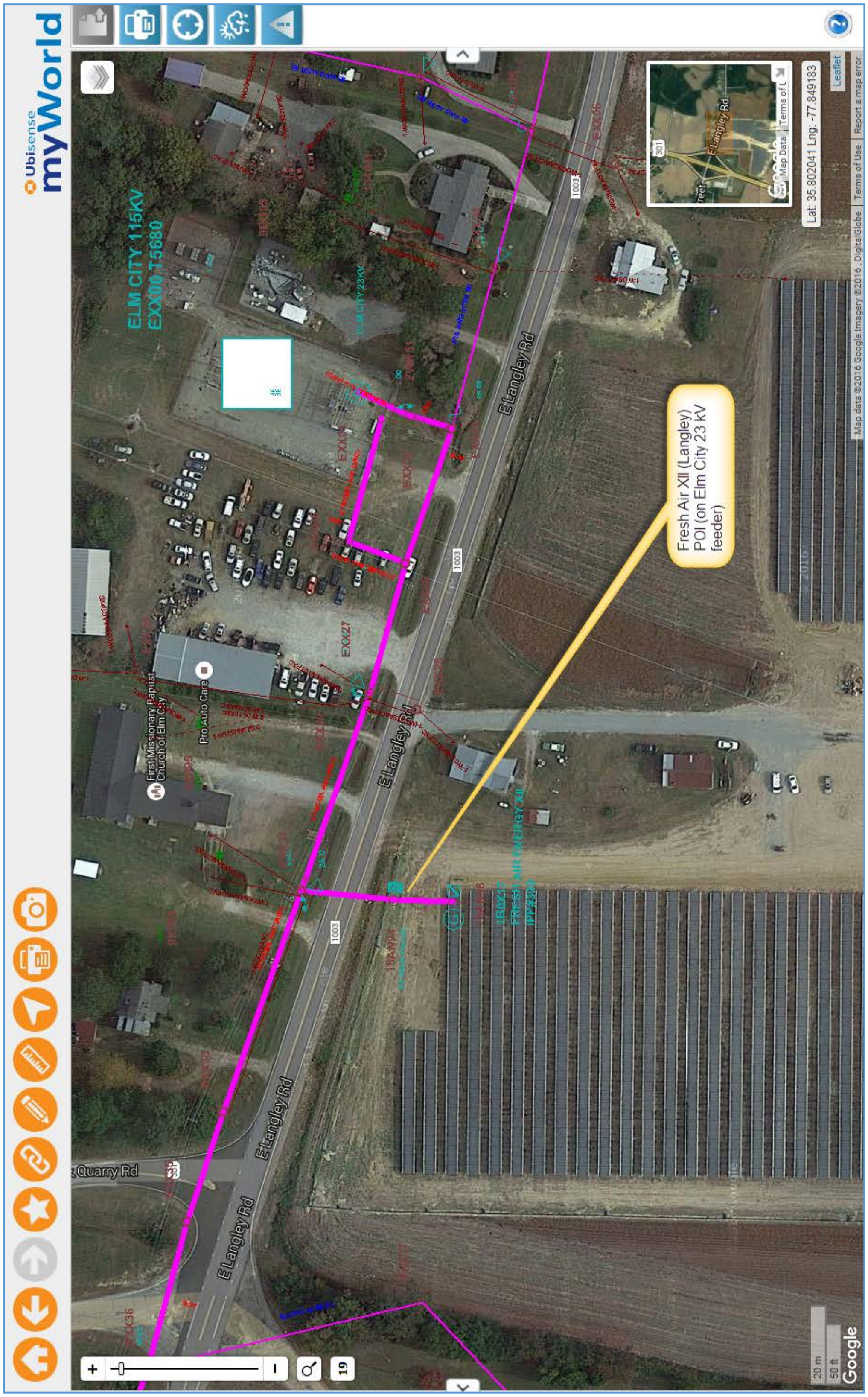


Exhibit 3-6b: local distribution system closeup, Wilson Farm 1

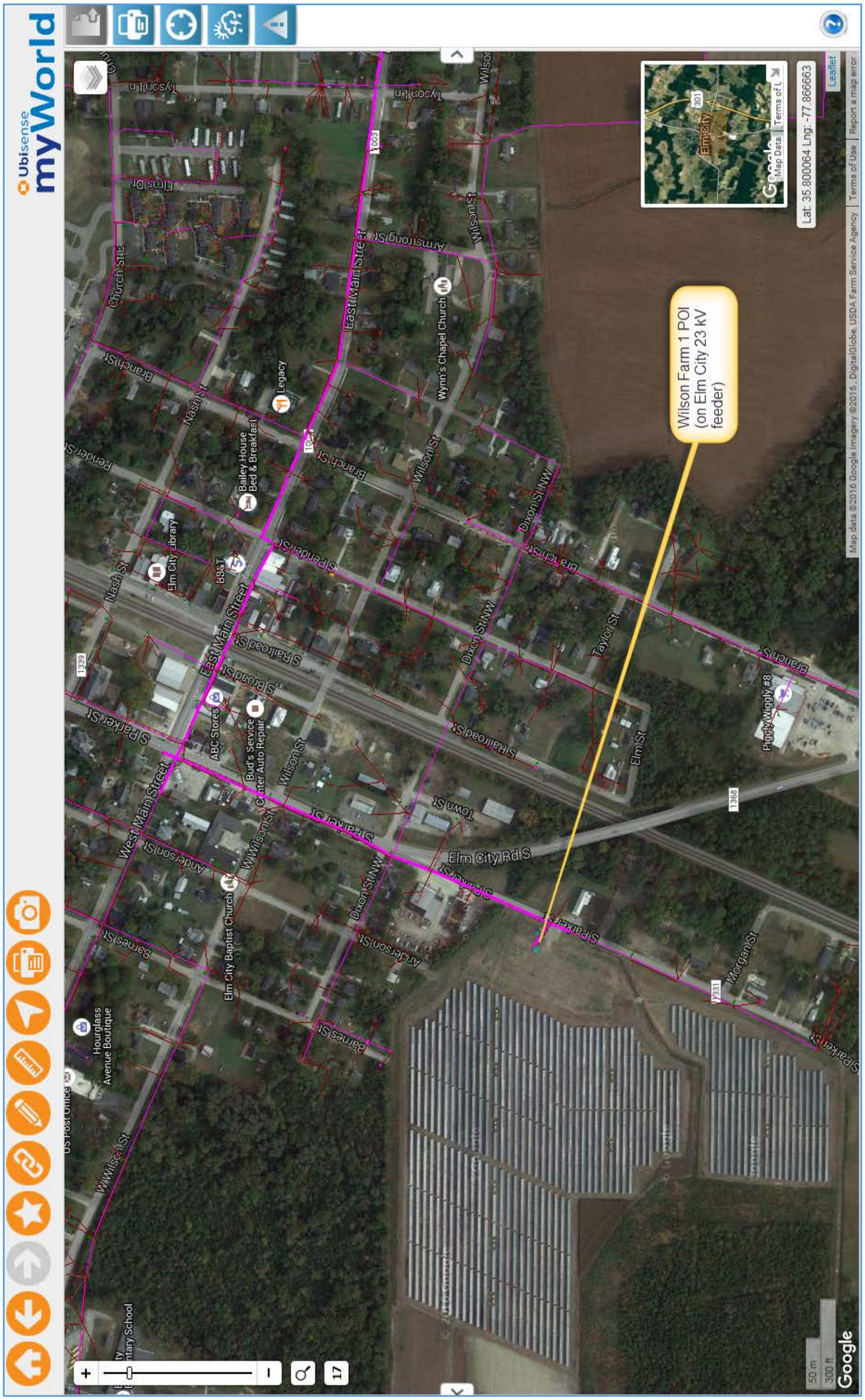


Exhibit 3-7a: Fresh Air XII one-line diagram excerpt

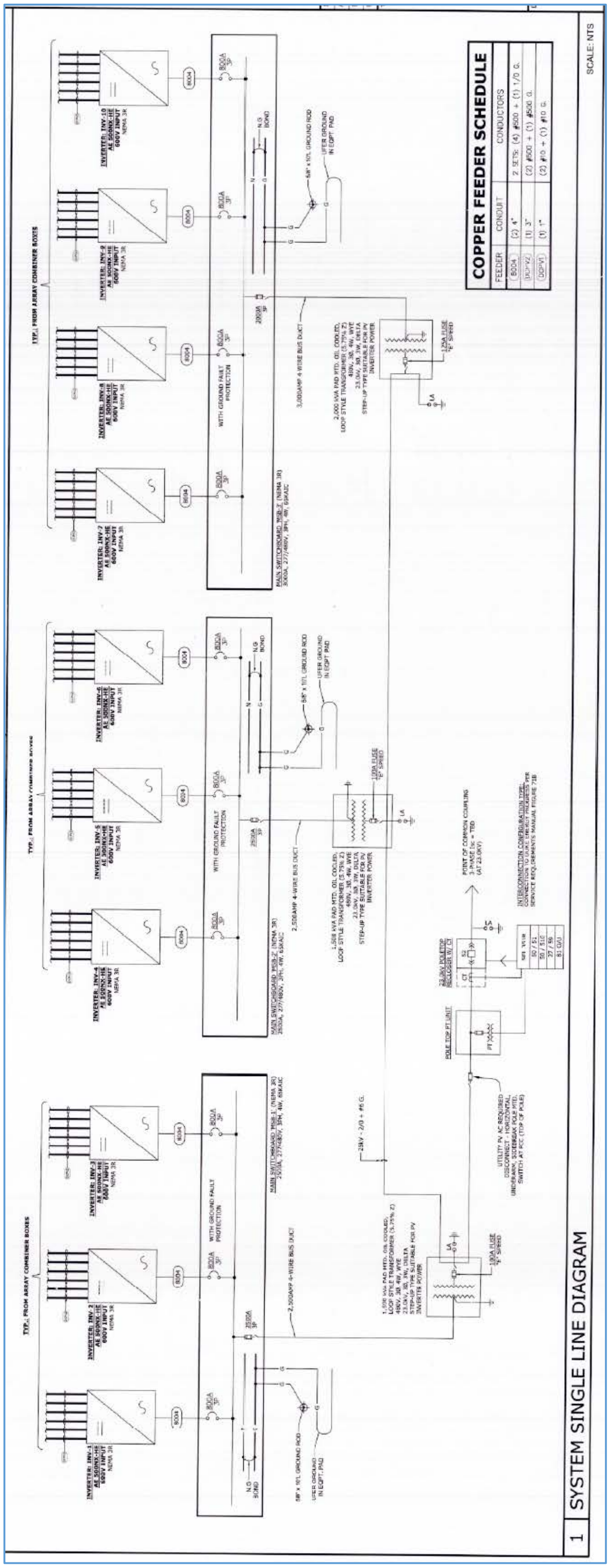
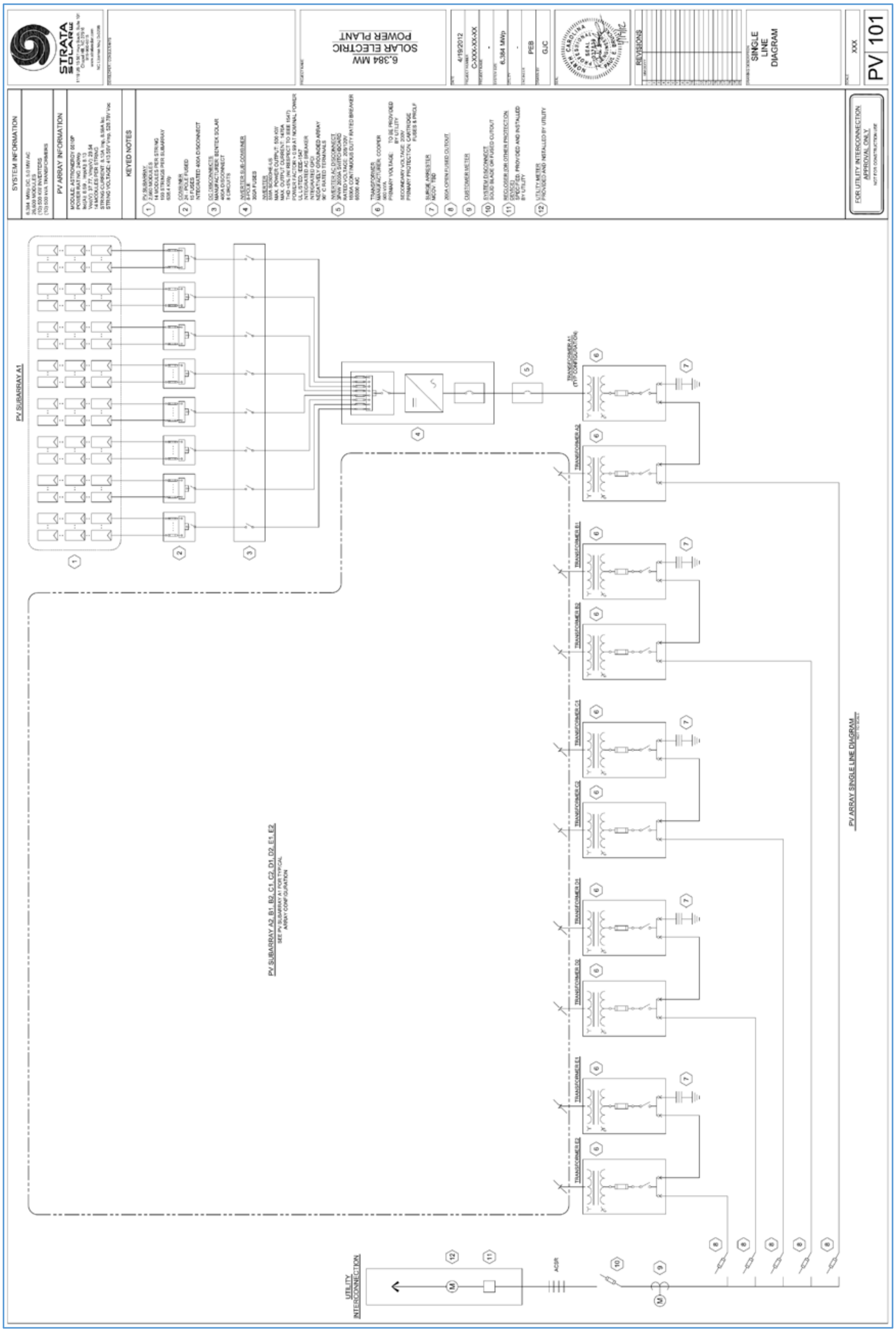


Exhibit 3-7b: Wilson Solar Farm one-line diagram



PUBLIC STAFF DATA REQUEST
July 8, 2016

DUKE ENERGY CAROLINAS, LLC AND DUKE ENERGY PROGRESS, LLC
Interconnection process changes

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Questions related to Duke Energy's changes to interconnection study review process to address power quality issues, as presented on June 24, 2016

Power Quality Incident #4: 5 MW solar farm / Lagrange 115KV substation

1. Please provide a brief summary of each of the power quality incidents on the DEC and DEP system that have occurred in the past two years that may have involved the addition of distributed generation systems, including the following:
    a. Date of the incident.
        i. February 16, 2016 (Summer 2015 – Feb 2016)

    b. Description of the incident, including specific details on any outages or power fluctuations that occurred.
        i. In February 2016, the Wayne III solar farm operator complained to Duke Energy about production interruptions that had been occurring since summer 2015, due to frequent tripping of Duke Energy owned recloser at the point of interconnection (POI). There were no faults related to the recloser operations. After investigation, Duke Energy engineers discovered correlation with the closing of a 600 kVAR capacitor bank about 0.3 miles away from the solar farm POI.

           Note Exhibit 4-1, which depicts the sequence of actions of one typical event. The event starts with a capacitor bank switching that produces an oscillatory ring wave as part of a normal closing operation. The majority of the inverters at the solar farm reacted with instantaneous tripping. After about 1 second, these tripped inverters attempted to restart and then began to ramp up their current output. After about 0.6 seconds into this ramping period, the interconnection recloser trips on its load encroachment[1] function and opens. After a 3 minute delay, the recloser closes and the inverters start coming back online.

The PQ meter record of the capacitor bank switching event is shown in Exhibit 4-2. At the moment of capacitor bank closing, there is a drop in instantaneous voltage, and the inverters respond to the low voltage and then trip almost instantaneously.

After these events were recorded, Duke Energy engineers participated in several conference calls with the generator site owner & operator. The inverter manufacturer reviewed the data gathered by Duke Energy and stated that the IGBT protection circuitry was what caused the inverters to instantaneously respond with an instantaneous overcurrent trip. The inverter manufacturer subsequently agreed that such operation, for a capacitor bank nearby, was undesirable. They stated that an inverter module replacement and associated firmware upgrade could likely fix the problem, but no specific commitments were made. The inverter manufacturer also stated that they had seen such incidents before, but typically in "weak grid" interconnections.

Duke Energy proceeded to review the impact of temporarily disabling the nearby capacitor bank in order to allow better operation of the facility. DEP Grid Management reviewed this and determined that temporarily disabling the capacitor bank would not result in customer voltages outside of regulatory limits, although it could have an impact to DSDR loss reduction capability on the feeder.

c. Utility customer that was impacted.
    i. No specific utility customer complaints were noted from this incident; however, every interconnection recloser trip event de-energized the 5 MVA of transformer capacity, which then required a following energization when the interconnection recloser closed back in. Based on knowledge gained recently with large solar farms, frequent energization of large transformation risks extended periods (> 10 cycles) of harmonic distortion, which can have impact to surrounding customers. Furthermore, such operation of a generating facility is clearly not expected nor acceptable for sustainable future operations for the distribution feeder nor the generator facility.

d. Utility equipment, if any, that was impacted.
    i. No utility equipment was noted to have suffered damage.

e. Description of any damage suffered by the utility or its customer(s).

[1] Load encroachment provides a user-settable phase-angle window in which the positive-sequence directional element is blocked. Load encroachment provides the benefit of tripping if the generators operate outside of their rated power factor operating range, which also serves as an anti-islanding function.

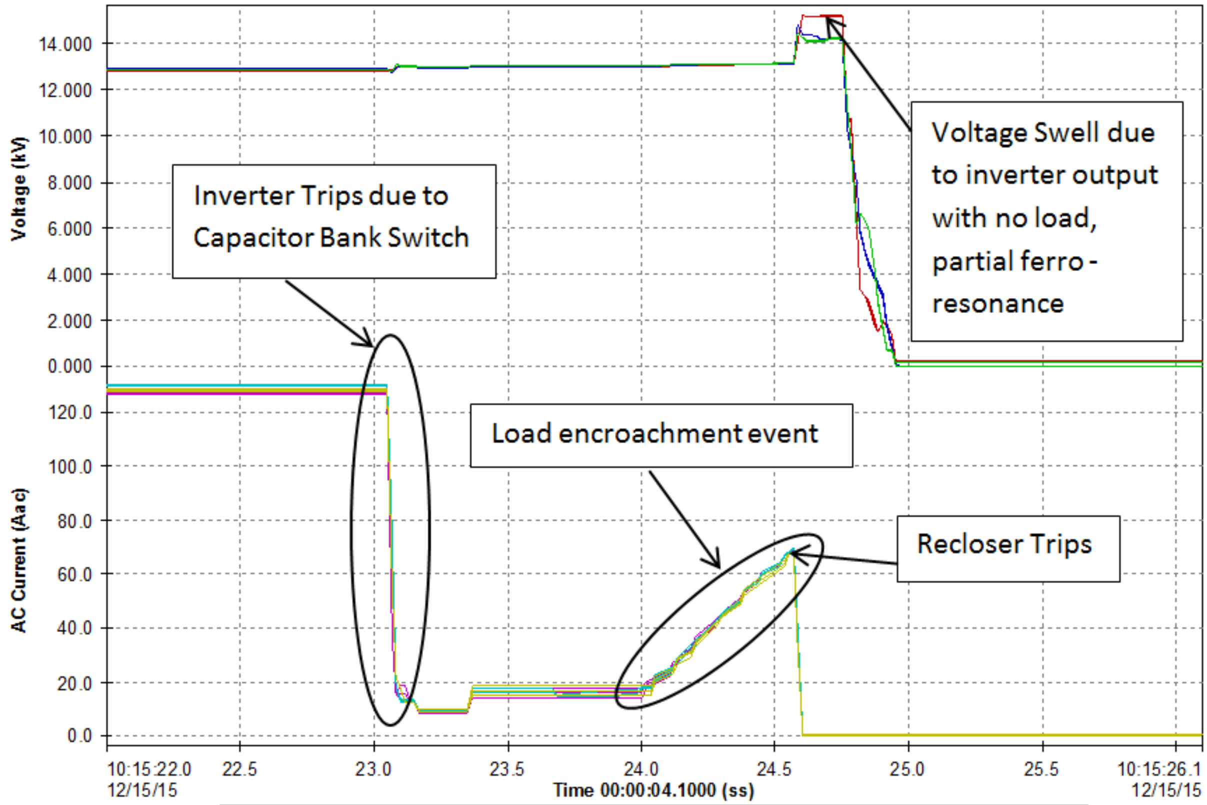
i. No other utility or customer impact was reported so far, but of course the generator owner has suffered production losses. As stated earlier, other customers could also be seeing undesired excessive voltage changes or transient harmonic voltages conditions each time the facility trips offline and returns to service.

f. Description of the substation, transformer, and other equipment on the substation or feeder.
   i. See Exhibit 4-3 for a one-line diagram of the Lagrange 115 kV substation. The transformer is a 115 kV – 12 kV, 15 MVA capacity (nominal nameplate rating), with two stages of fans to allow loading at 20 MVA and 25 MVA, respectively. The station is equipped with a three phase bus regulator, and there are three feeder breakers to serve the Beston Road 12 kV feeder, the Walnut Creek 12 kV feeder, and the Lagrange City 12 kV feeder.

g. Details of the distributed generation systems interconnected on the substation or feeder involved that may have contributed to the incident.
   i. Interconnected at DEP pole ID# 181X46, the Wayne III Solar farm is a 5 MW PV generating facility. See Exhibits 4-4 and 4-5 for the distribution feeder topology that serves the facility. The POI is on the Beston Road 12 kV feeder, approximately 3.5 miles in electrical distance from the substation.

      See Exhibit 4-6 for an excerpt of the facility's one-line diagram. The facility consists of two 1500 kVA transformers, each with an ABB Power-One Aurora Ultra-1500 inverter; and two 1000 kVA transformers, each with an ABB Power-One Aurora Ultra-1000 inverter, for a total of four transformers and four inverters.

Exhibit 4-1: The following graph depicts the entire event in detail. Duration of graph is 4.1 seconds



	Maximum	Minimum	Average		Maximum	Minimum	Average
Calc RMS Van - Vbn	15.292	0.002	9.027	Aac RMS of Ia	127.7	0.0	42.4
Calc RMS Van - Vcn	14.839	0.002	9.040	Aac RMS of Ib	130.5	0.0	43.4
Calc RMS Vbn - Vcn	14.511	0.000	9.041	Aac RMS of Ic	128.5	0.0	42.7

Exhibit 4-2: Waveform of the oscillatory ring wave from the capacitor bank switch. The current from the inverters on the current waveform below. Duration of graph is 94 milliseconds.

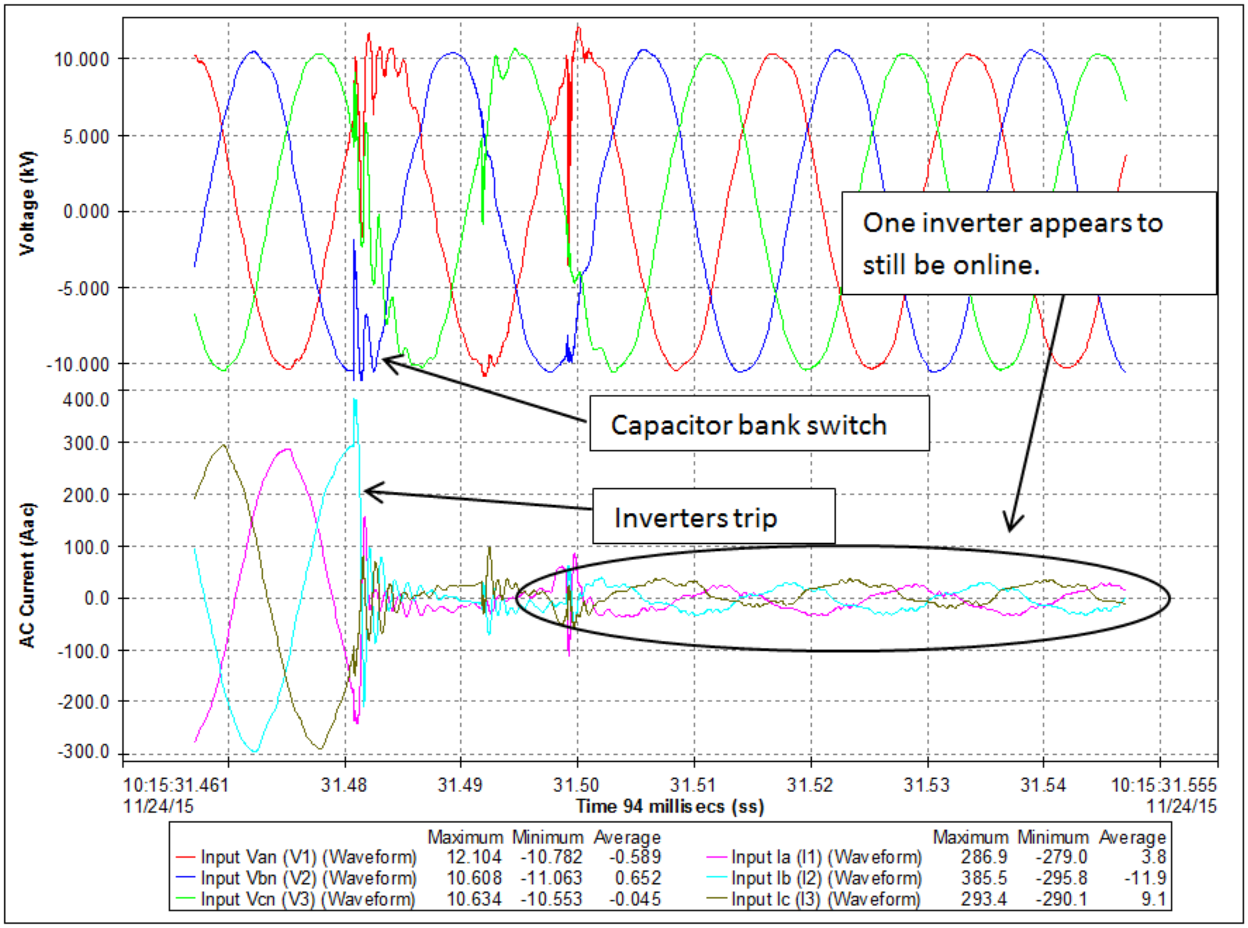


Exhibit 4-3: Lagrange 115 kV Substation, one-line diagram

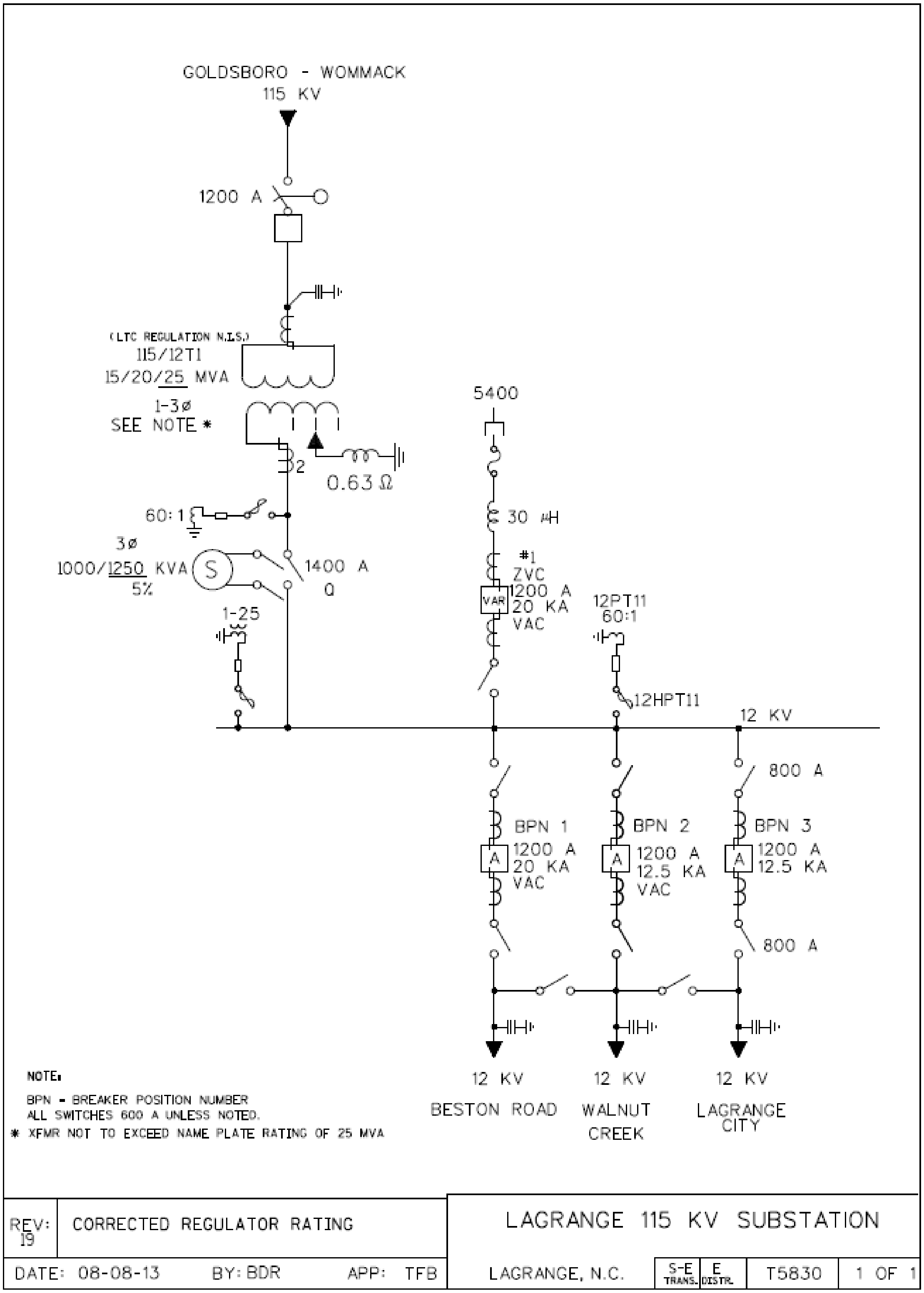


Exhibit 4-4: local distribution system

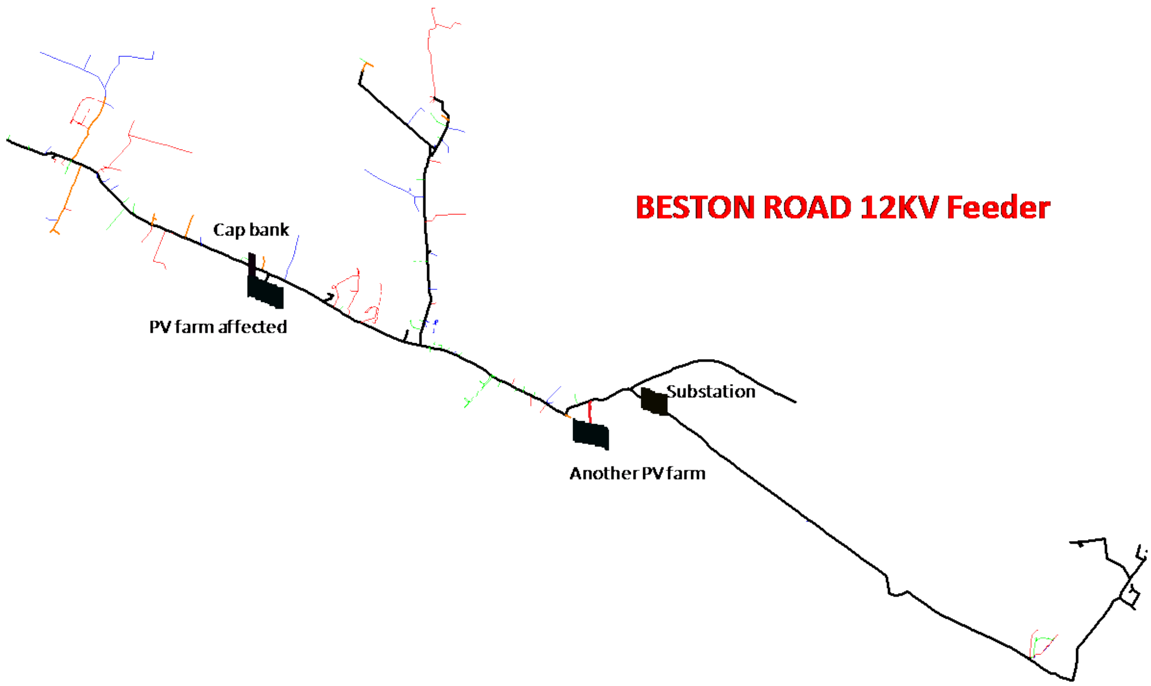


Exhibit 4-5: local distribution system closeup

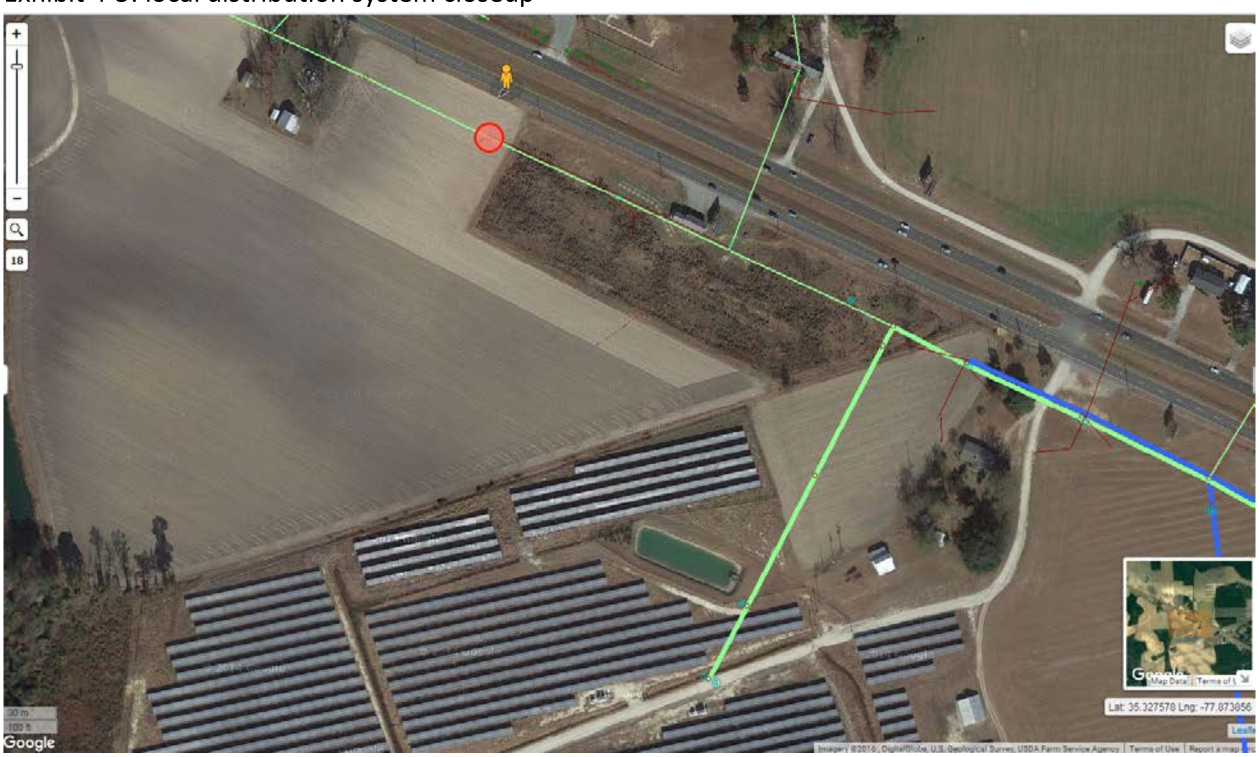
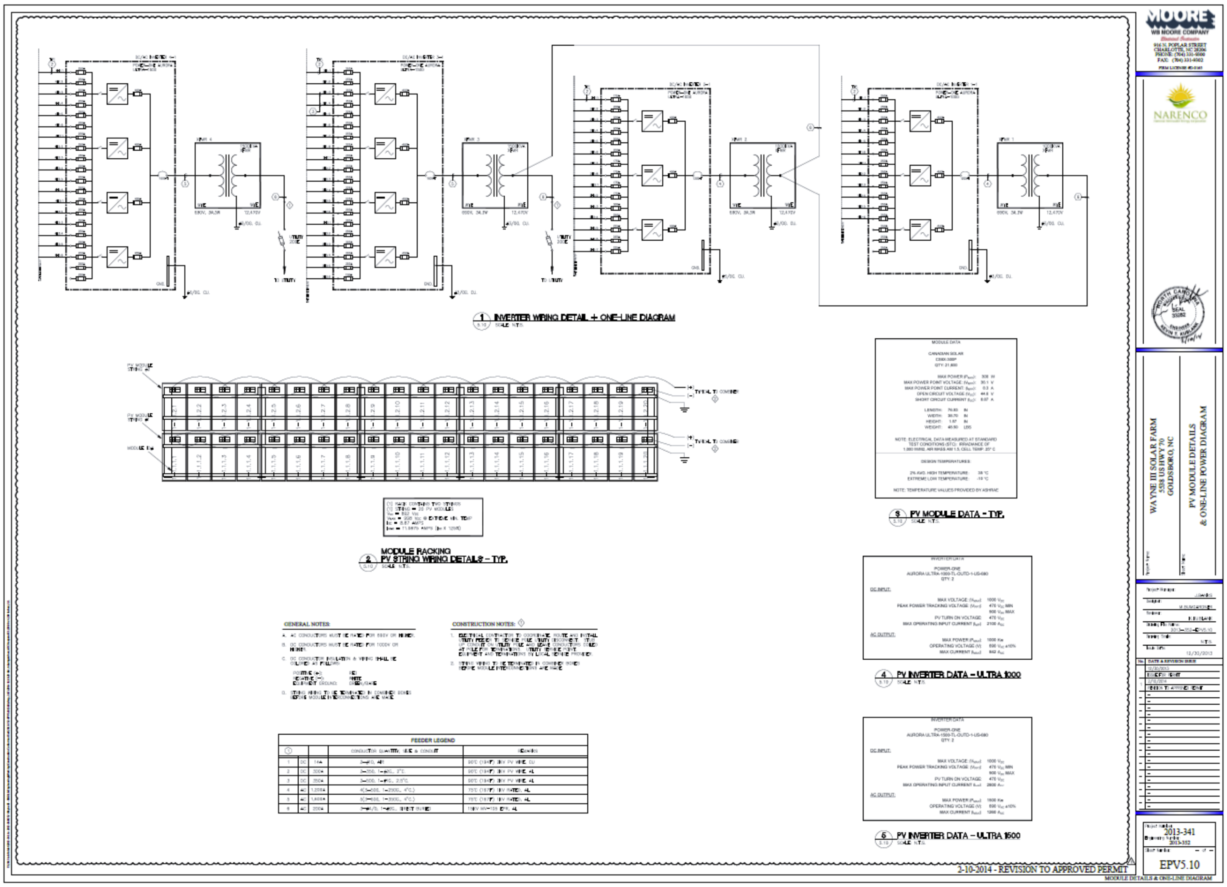


Exhibit 4-6: Wayne III solar one-line diagram excerpt



PUBLIC STAFF DATA REQUEST
July 8, 2016

DUKE ENERGY CAROLINAS, LLC AND DUKE ENERGY PROGRESS, LLC
Interconnection process changes

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Questions related to Duke Energy's changes to interconnection study review process to address power quality issues, as presented on June 24, 2016

Power Quality Incident #5: Mar 2011, 12 MW landfill gas plant / Roseboro 115 kV substation

1. Please provide a brief summary of each of the power quality incidents on the DEC and DEP system that have occurred in the past two years that may have involved the addition of distributed generation systems, including the following:
   a. Date of the incident.
      i. March 2011. NOTE: While this incident did not take place within the last two years, as specifically requested, Duke Energy desires to include this event as it serves instructional to demonstrate power quality incidents related to rotating machine installations.

   b. Description of the incident, including specific details on any outages or power fluctuations that occurred.
      i. The Black Creek Renewable Energy landfill gas generating facility, located at the Sampson County landfill between Roseboro and Clinton, began commercial operation on the Duke Energy Progress system in early March 2011.

         Not long after the facility began operation, the generator owner contacted DEP to complain of nuisance trip events. DEP engineers proceeded to look into the events, and they discovered that the DEP interconnection recloser at the site was tripping coincident with a nearby capacitor bank on the feeder. Further investigation revealed that the nuisance tripping took two forms: (1) the interconnection recloser was tripping due to a protection mechanism on the interconnection recloser that trips when phase angle swing is detected[1], or (2) generator kVAR limit relays were tripping the generators. See Exhibit 5-1 for a

[1] Duke Energy Progress reclosers utilize a protection function known as "load encroachment," which is designed to act as an anti-islanding protection function.

log of generator interconnection trip and close events, and see Exhibit 5-2 for a corresponding log of capacitor bank operations.

Ensuing discussions took place between Duke Energy Progress engineers and generator owner technical support employees and/or contractors. Duke Energy Progress engineers explained that when a nearby capacitor bank on the feeder would operate, there was sufficient phase angle swing to cause the aforementioned trip events. The generator representatives reported that their control system equipment would likely not be physically capable of responding fast enough for the capacitor bank switching events.

It turned out that Duke Energy Progress was in the midst of considering a project to remove the capacitor bank and replace it with two smaller capacitor banks. In addition, the utility offered to temporarily extend the time delay of the phase angle protection function.

ii. NOTE: This specific project is the subject of the technical paper “Maintaining Long Rural Feeders with Large Interconnected Distributed Generation,”[2] by Keary Dosier, P.E., and details a comprehensive narrative of this facility’s interconnection and post-interconnection operation.

c. Utility customer that was impacted.
   i. No specific utility customer complaints were noted from this incident; however, every interconnection recloser trip event de-energized the ~10 MVA of transformer capacity, which then required a following energization when the interconnection recloser closed back in. Based on knowledge gained recently with large solar farms, frequent energization of large transformation risks extended periods (> 10 cycles) of harmonic distortion, which can have impact to surrounding customers. Furthermore, such operation of a generating facility is clearly not expected nor acceptable for sustainable future operations for the distribution feeder nor the generator facility.

d. Utility equipment, if any, that was impacted.
   i. No utility equipment was noted to have suffered damage.

e. Description of any damage suffered by the utility or its customer(s).
   No specific damage was known to have been suffered by the utility nor its customers.

f. Description of the substation, transformer, and other equipment on the substation or feeder.

[2] K. R. Dosier, "Maintaining long rural feeders with large interconnected distributed generation," *Rural Electric Power Conference (REPC), 2014 IEEE*, Fort Worth, TX, 2014, pp. A2-1-A2-4. Also see: http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=6842197&isnumber=6842195

i. See Exhibit 5-3 for a one-line diagram of the Roseboro 115 kV substation. This substation is fairly typical of legacy Duke Energy Progress substations. The transformer is a 115 kV – 24 kV, 15 MVA capacity (nominal nameplate rating), with two stages of fans to allow loading at 20 MVA and 25 MVA, respectively. The station is equipped with a three phase bus regulator, and there are three feeder breakers to serve the Autryville, Roseboro, and Salemburg 23 kV feeders.

g. Details of the distributed generation systems interconnected on the substation or feeder involved that may have contributed to the incident.

i. Interconnected at DEP pole ID# 15FX18, the Black Creek Renewable generating facility is a 12 MW rotating machine generating facility. See Exhibits 5-4 and 5-5 for the distribution feeder topology that serves the facility. The POI is on the Roseboro feeder, approximately 39,000’ (7.4 miles) in electrical distance from the substation.

See Exhibit 5-6 for an excerpt of the facility’s one-line diagram. The facility design consists of a single 10 MVA transformer (future 14 MVA fanned capability), and up to six 1.6 MW / 2.0 MVA generators.

Exhibit 5-1: Log of interconnection recloser trip and close events. NOTE: Every event with "ABCT" to the right hand side of the time stamp indicates a three-phase trip event of the recloser. Every event that follows, typically within three minutes, indicates energization of the facility and a 10 MVA transformer inrush event.

Device: **SAMPSON CO LANDFILL INTERTIE**

Event History

1	03/16/2011 10:35:35.377 CA
2	03/16/2011 10:32:35.313 ABC T
3	03/16/2011 05:49:46.807 CA
4	03/16/2011 05:46:46.733 ABC T
5	03/16/2011 03:19:05.178 CA
6	03/16/2011 03:16:05.179 ABC T
7	03/16/2011 03:08:59.685 BC
8	03/16/2011 03:05:59.603 ABC T
9	03/16/2011 02:54:08.036 AB
10	03/16/2011 02:51:07.989 ABC T
11	03/16/2011 02:18:19.104 AB
12	03/16/2011 02:15:19.076 ABC T
13	03/16/2011 02:09:23.532 BC
14	03/16/2011 02:06:23.416 ABC T
15	03/15/2011 23:54:40.092 CA
16	03/15/2011 23:51:40.034 ABC T
17	03/14/2011 20:08:56.449 AB
18	03/14/2011 20:05:56.437 ABC T
19	03/14/2011 19:55:27.868 CA
20	03/14/2011 19:52:27.823 ABC T
21	03/14/2011 18:02:02.430 BC
22	03/14/2011 17:59:02.413 ABC T
23	03/14/2011 17:48:31.038 AB
24	03/14/2011 17:45:30.968 ABC T
25	03/14/2011 17:34:29.433 AB

Exhibit 5-2: Log of capacitor control system, with correlated recloser trip events shown in red.

DIS#	Op Date	GMT (recloser)	Gen trip?	Command	Reason
2FQ98	Mon 03/14/2011 13:45	Mon 03/14/2011 17:45	YES	OPEN	VAR
		Mon 03/14/2011 17:59	YES		
2FQ98	Mon 03/14/2011 15:45	Mon 03/14/2011 19:45		CLOSE	VAR
		Mon 03/14/2011 19:52	YES		
2FQ98	Mon 03/14/2011 16:01	Mon 03/14/2011 20:01		OPEN	VAR
		Mon 03/14/2011 20:05	YES		
2FQ98	Tue 03/15/2011 00:01	Tue 03/15/2011 04:01		OPEN	MAN
2FQ98	Tue 03/15/2011 19:45	Tue 03/15/2011 23:45		CLOSE	VAR
		Tue 03/15/2011 23:51	YES		
2FQ98	Tue 03/15/2011 20:00	Wed 03/16/2011 00:00		OPEN	VAR
2FQ98	Tue 03/15/2011 22:00	Wed 03/16/2011 02:00		CLOSE	VAR
		Wed 03/16/2011 02:06	YES		
2FQ98	Tue 03/15/2011 22:15	Wed 03/16/2011 02:15	YES	OPEN	VAR
2FQ98	Tue 03/15/2011 22:45	Wed 03/16/2011 02:45		CLOSE	VAR
		Wed 03/16/2011 02:51	YES		
2FQ98	Tue 03/15/2011 23:00	Wed 03/16/2011 03:00		OPEN	VAR
		Wed 03/16/2011 03:05	YES		
2FQ98	Tue 03/15/2011 23:15	Wed 03/16/2011 03:15	YES	CLOSE	VAR
2FQ98	Wed 03/16/2011 01:45	Wed 03/16/2011 05:45	YES	OPEN	VAR
2FQ98	Wed 03/16/2011 06:31	Wed 03/16/2011 10:31	YES	CLOSE	VAR

Exhibit 5-3: Roseboro 115 kV Substation, one-line diagram

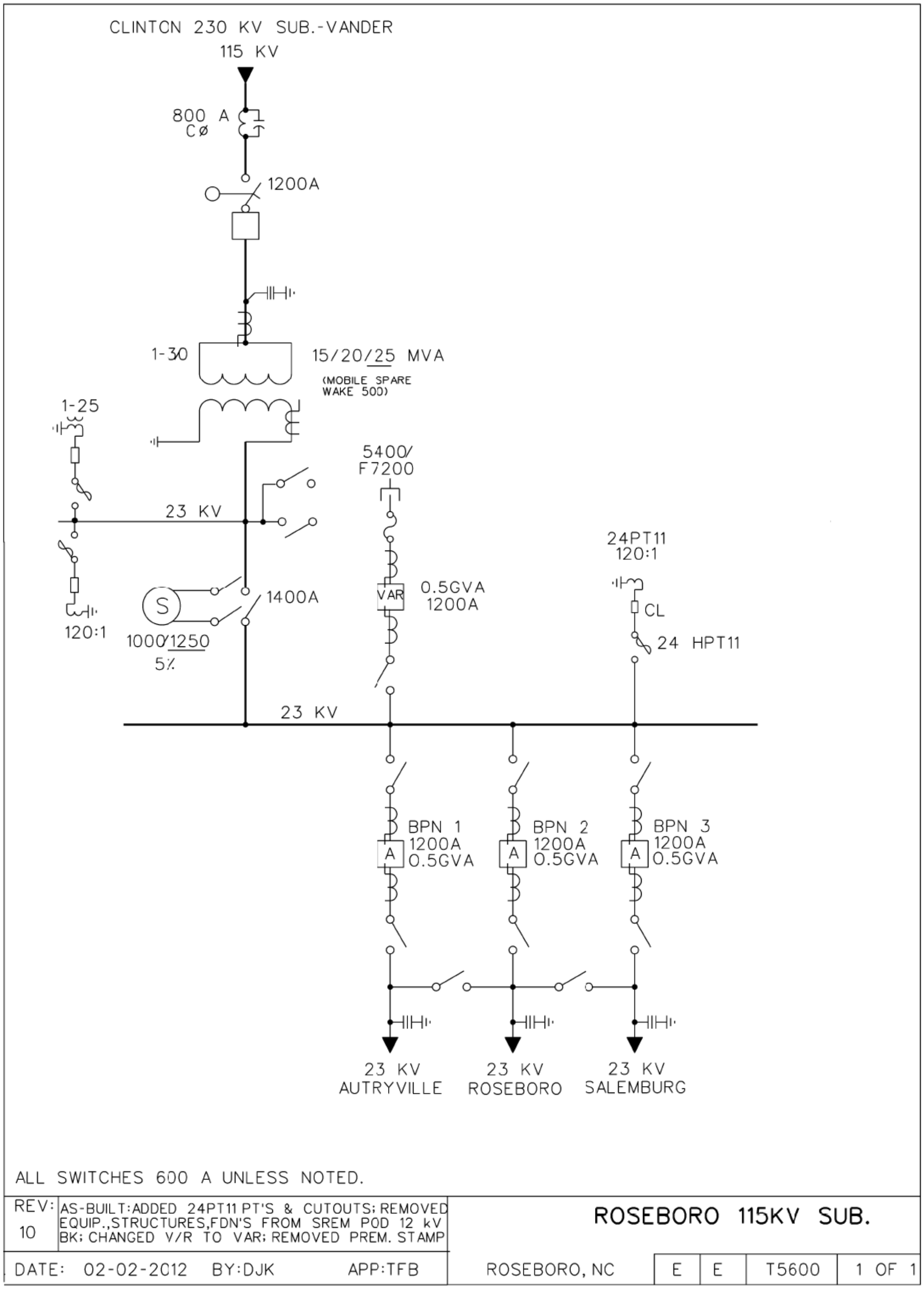


Exhibit 5-4a: local distribution system

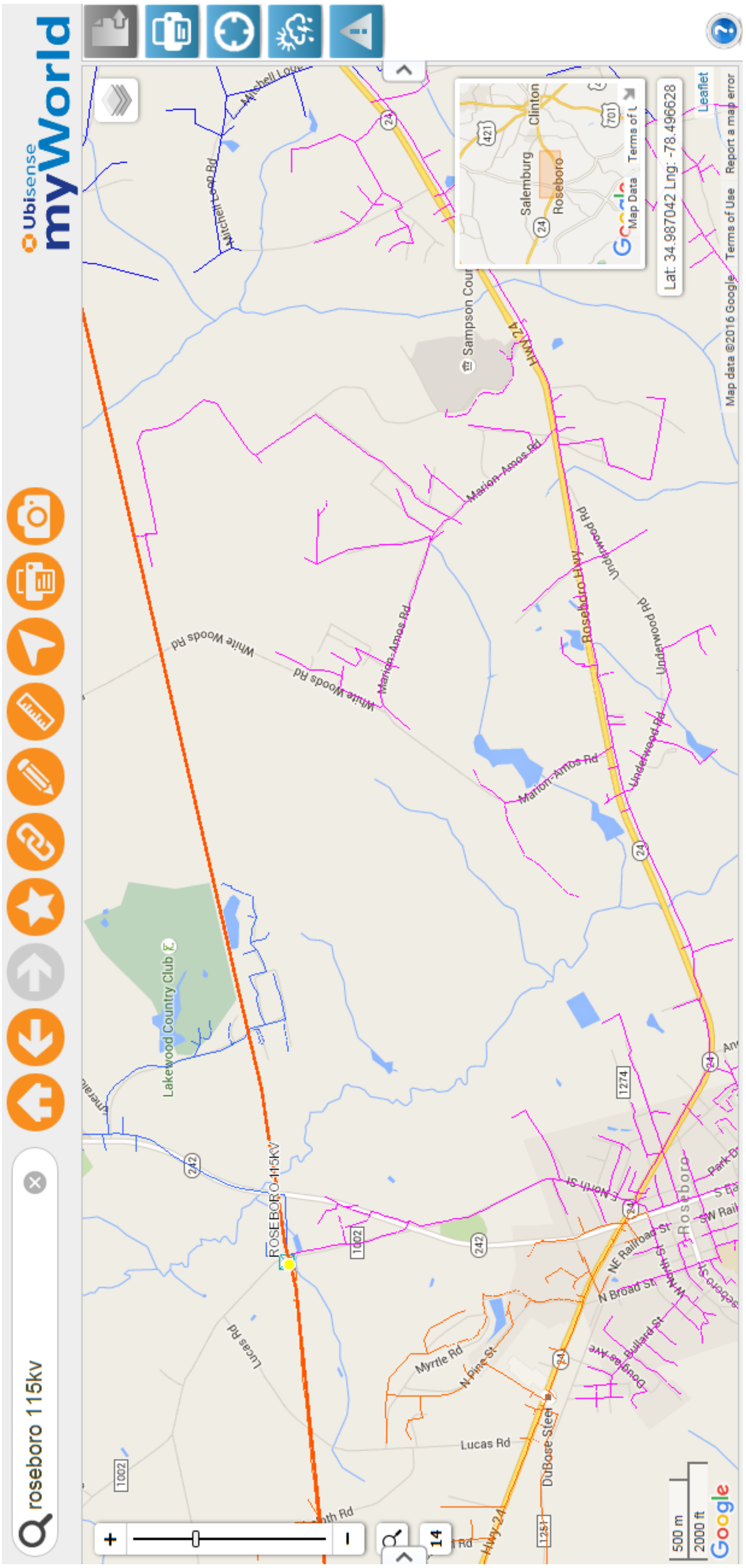


Exhibit 5-4b: local distribution system

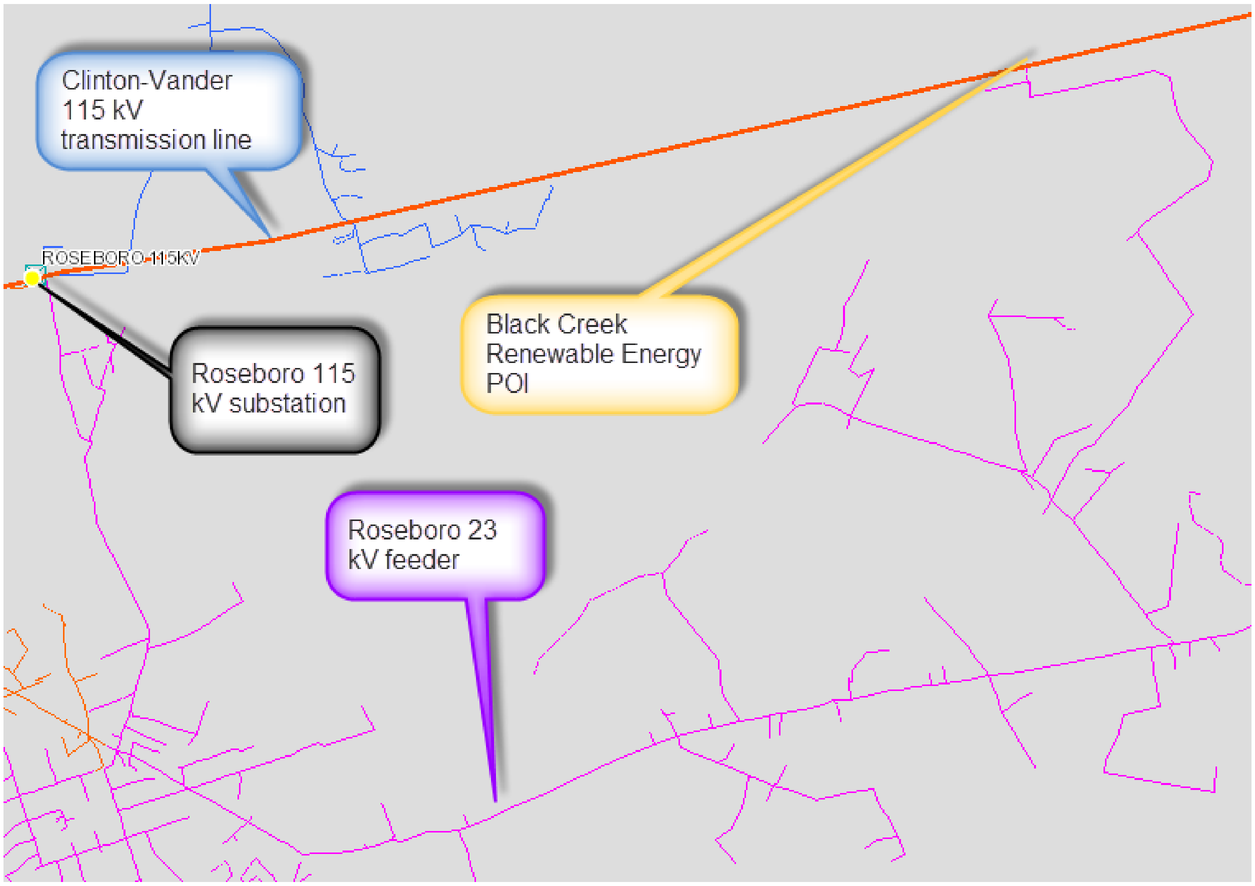


Exhibit 5-5: local distribution system closeup

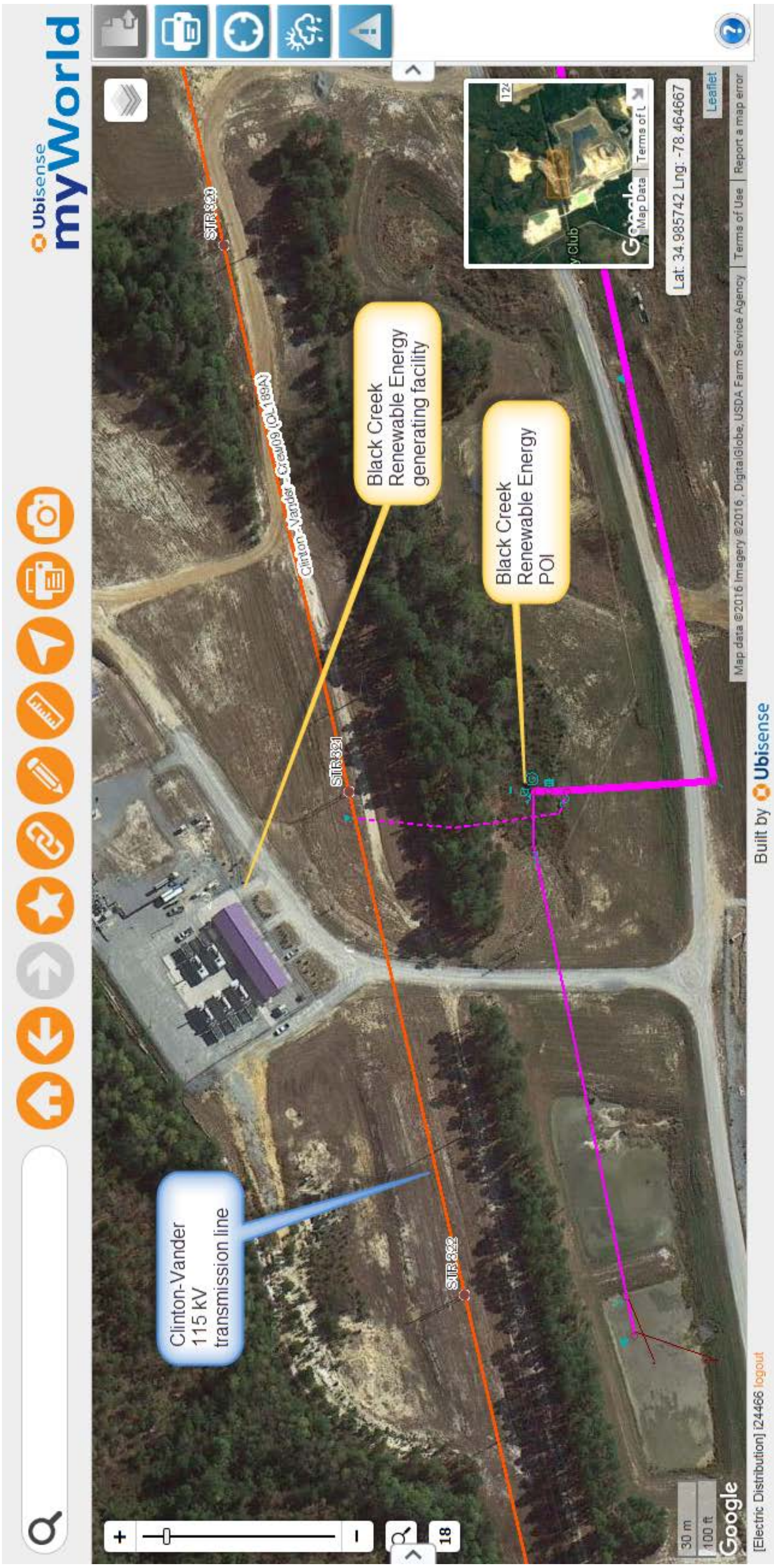
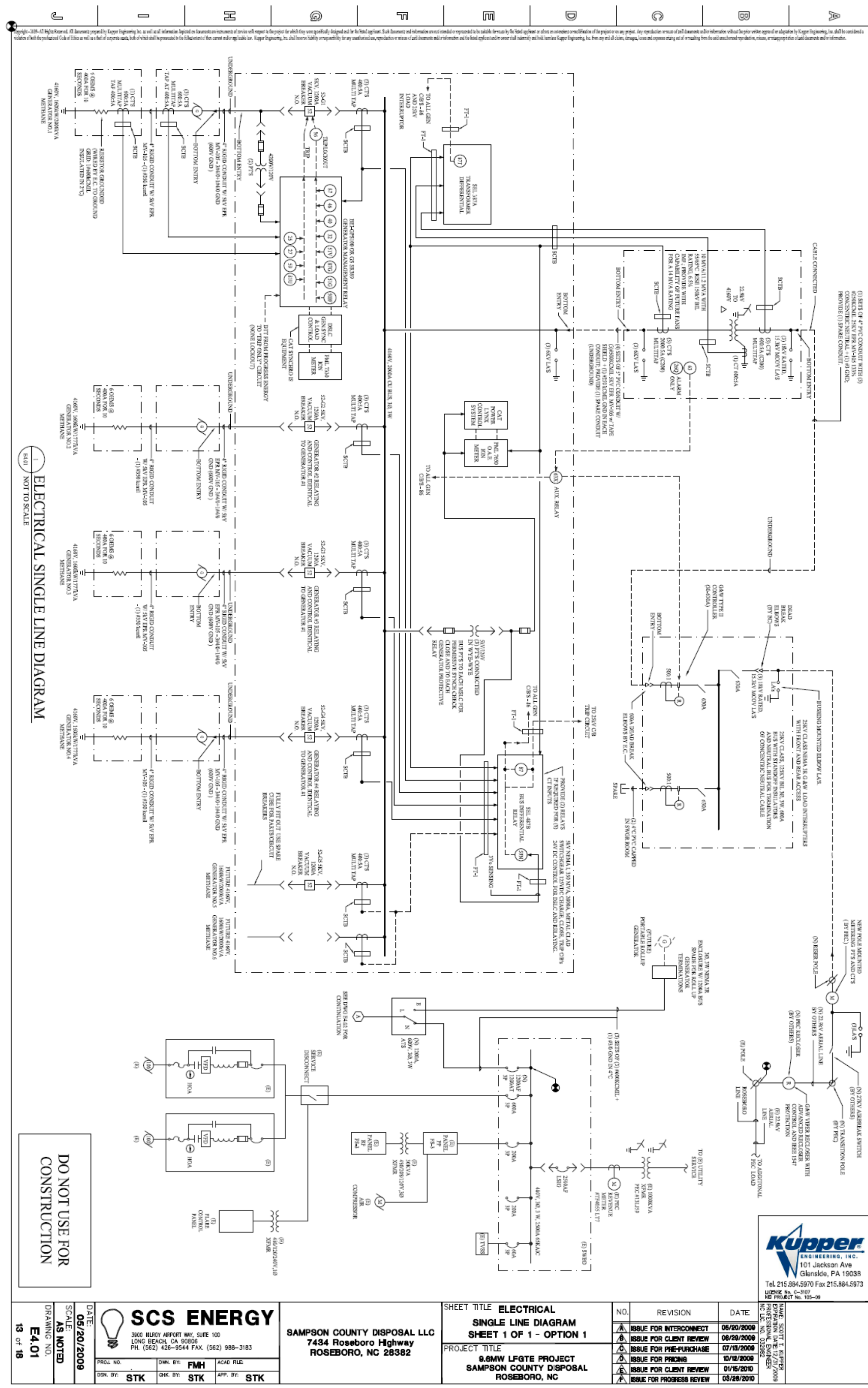


Exhibit 5-6: Black Creek Renewable one-line diagram excerpt



PUBLIC STAFF DATA REQUEST
July 8, 2016

DUKE ENERGY CAROLINAS, LLC AND DUKE ENERGY PROGRESS, LLC
Interconnection process changes

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Questions related to Duke Energy's changes to interconnection study review process to address power quality issues, as presented on June 24, 2016

Power Quality Incident #6: 4 MW solar farm / Belwood Retail substation

1. Please provide a brief summary of each of the power quality incidents on the DEC and DEP system that have occurred in the past two years that may have involved the addition of distributed generation systems, including the following:
   a. Date of the incident.
      i. December 2012 – March 2014

   b. Description of the incident, including specific details on any outages or power fluctuations that occurred.
      i. December 2012
         1. Belwood Retail 4MW PV farm goes online; served via Waco No 2 44kV Line

      ii. February 2013
         1. Belwood PV farm reports high voltage is tripping their recloser at the PV site
         2. Belwood Retail Tap change is issued to lower the 12kV voltage serving the PV farm

      iii. April 2013
         1. Belwood 44kV cap setting change (lower call on/off) in response to Rutherford EMC reports of high voltage (including during peak)
         2. Rutherford EMC has two 44kV deliveries served from the Waco No 2 44kV Line, one delivery on the Waco No 1 44kV Line. Rutherford EMC takes a 44kV delivery at each of these delivery points to serve a 44kV substation between 3-5 miles away from the delivery point (increased losses at co-op substations).

iv. July 2013
   1. Duke Energy technicians report low voltage and phase imbalance on the 12kV circuits out of Belwood Retail
   2. Duke Energy technicians report that the Belwood 12kV station capacitor is online at all times; claims it never operated prior to the Belwood PV being online.
   3. Cherryville Tie Tap change issued to lower the 44kV voltage on the Waco No 1 44kV Line
      a. Belwood Retail transformer tap returned to prior position

v. September 2013
   1. Cherryville Tie 44kV capacitor settings changed in response to the Cherryville Tie tap change from July 2013

vi. December 2013
   1. Waco Retail 2MW PV farm goes online on the Waco No 1 44kV Line

vii. January 2014
   1. Belwood 44kV capacitor setting change issued in response to low voltage reports at Flay Retail
   2. Portable 44kV capacitor installed at Flay Retail during Polar Vortex (winter peak)

viii. March 2014
   1. Rutherford EMC reports low voltage at their two deliveries on the Waco No 2 44kV Line during the Polar Vortex
   2. Negotiations begin with Rutherford EMC to bring 100kV to the area and allow Rutherford EMC to convert three deliveries in the area from 44kV to 100kV service.
   3. Recorders installed near Belwood 44kV capacitors to monitor operation

c. Utility customer that was impacted.
   i. Rutherford EMC, a wholesale customer, was impacted as stated above.

d. Utility equipment, if any, that was impacted.
   i. No utility equipment was noted to have suffered damage.

e. Description of any damage suffered by the utility or its customer(s).
   i. No damage has been documented to date.

f. Description of the substation, transformer, and other equipment on the substation or feeder.
   i. See Exhibit 6-1 for a one-line diagram of the Belwood Retail substation. The transformer is a 44 kV – 12 kV, 6 MVA capacity (nominal nameplate rating. The

station is equipped with a single phase regulators for each feeder exit. There are two feeder circuit exits: circuit 1202 and circuit 1203.

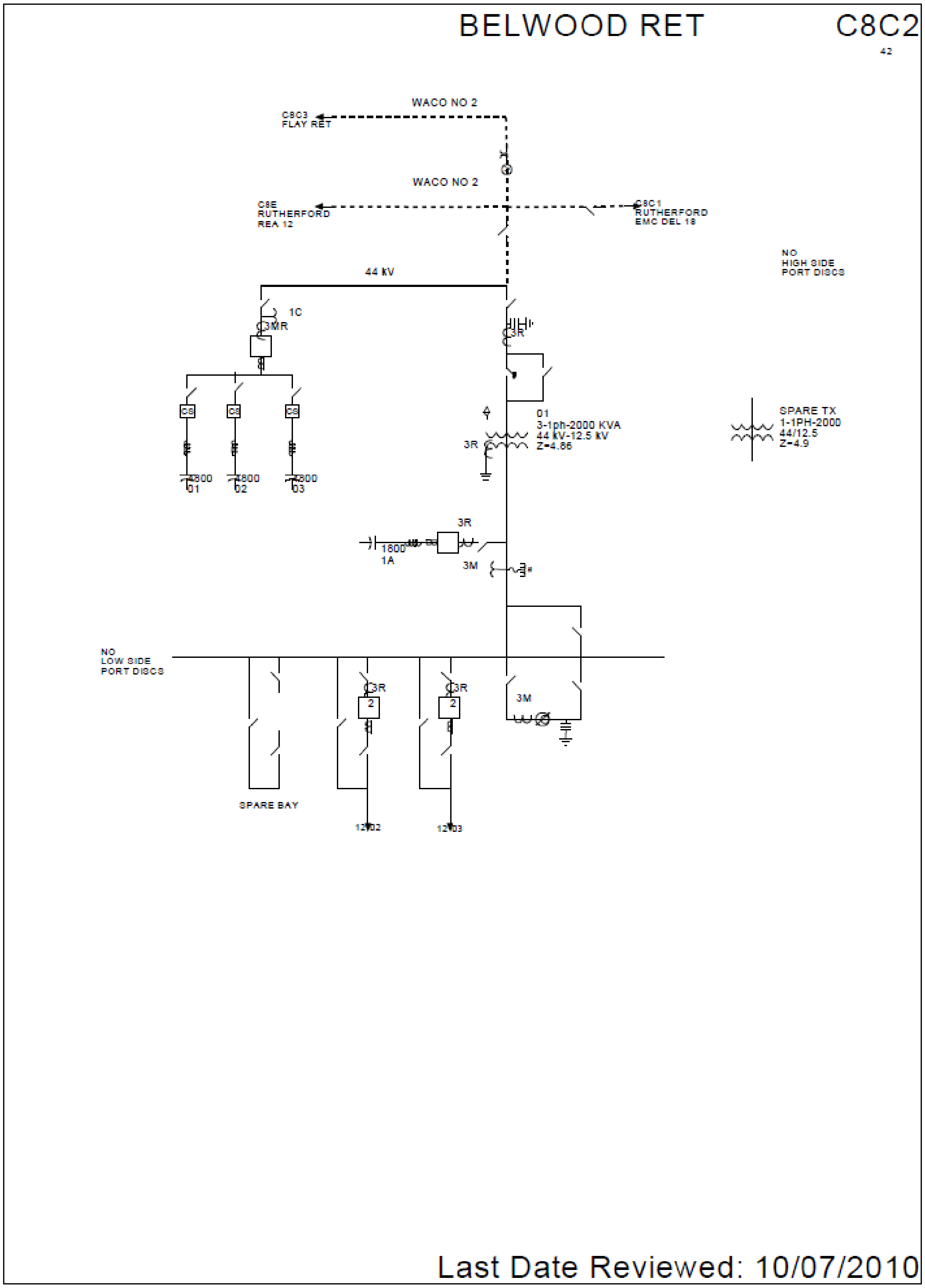
g. Details of the distributed generation systems interconnected on the substation or feeder involved that may have contributed to the incident.

   i. Interconnected just south of substation, the Belwood Farm solar farm is a 4 MW PV generating facility. See Exhibits 6-2 and 6-3 for the distribution feeder topology that serves the facility. The POI is on circuit 1202, approximately 500' in electrical distance from the substation.

      See Exhibit 6-4 for an excerpt of the facility's one-line diagram. The facility consists of four 1000 kVA transformers, each with two SMA 500U inverters.

Exhibit 6-1: Belwood Retail substation

PROPRIETARY COMPANY INFORMATION



Duke
Energy

Exhibit 6-2: Local distribution system

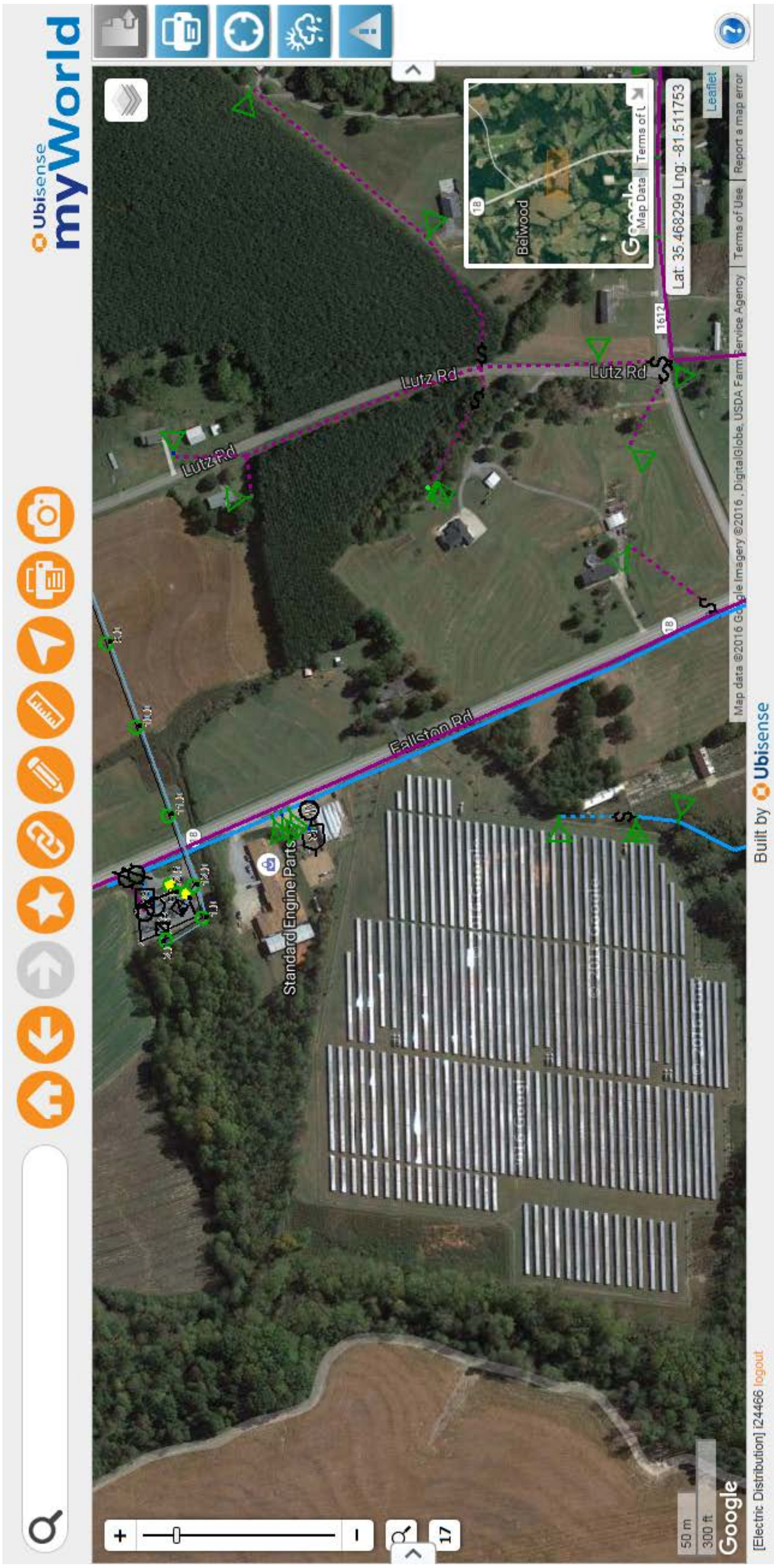


Exhibit 6-3: Local subtransmission/transmission system

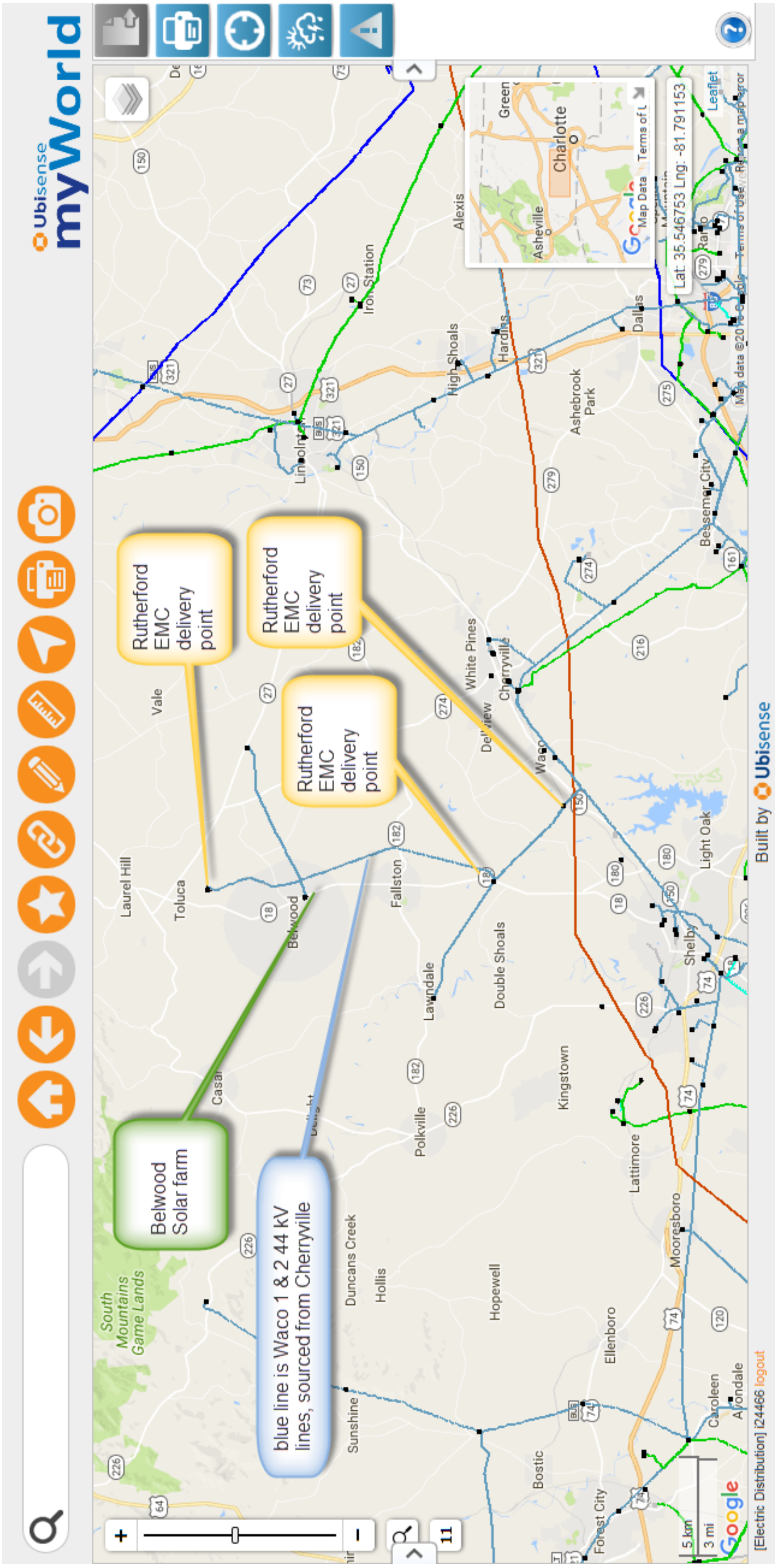
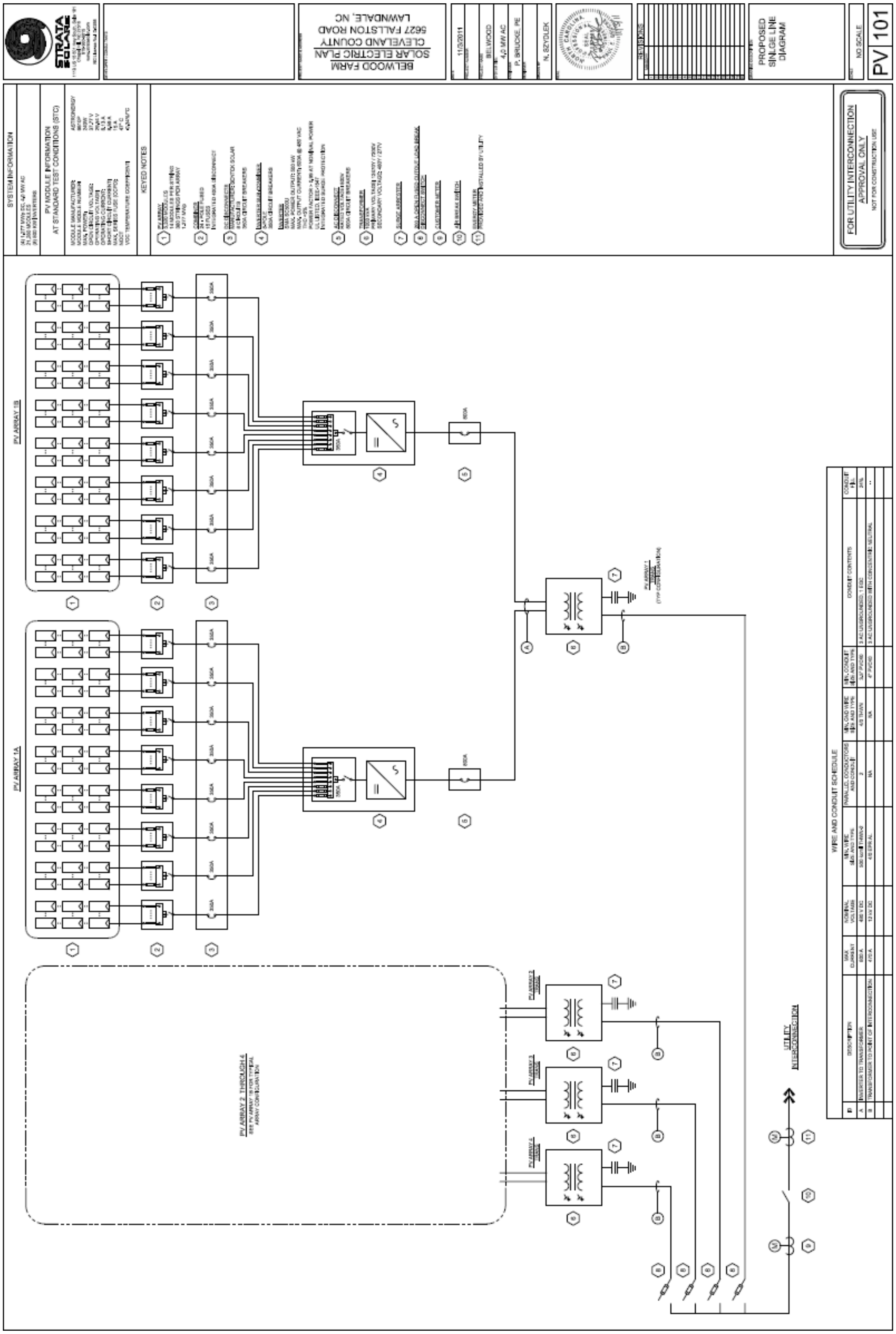


Exhibit 6-3: Belwood Farm solar one-line diagram excerpt



CERTIFICATE OF SERVICE

I certify that a copy of Duke Energy Carolinas, LLC and Duke Energy Progress, LLC's Response to September 8, 2016 Order Requiring Response and Requesting Comments in Docket No. E-100, Sub 101, has been served by electronic mail, hand delivery or by depositing a copy in the United States mail, postage prepaid to the following parties:

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This the 22nd day of September, 2016

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